International Journal on Teaching and Learning Mathematics
2020, Vol. xx, No. x, pp. xx-xx
P-ISSN: 2621-2188, E-ISSN: 2621-2196

Exploration of plane and solid figures in Four Umpak Buildings at Penataran Temple

Faizal Chandra[1*], Marhayati[2], Asfira Zakiatun Nisa'[3]

[1]SMPI Annuriyah Malang, Indonesia

[2]Universitas Islam Negeri Maulana Malik Ibrahim Malang, Indonesia

[3]MA Al Irtiqo', Indonesia

ARTICLE INFO
Original Article
Received: 05, 03. 2024.
Revised: 18, 03. 2024.
Accepted: 25, 03. 2024.
doi: 10.18860/ijtlm.v6i2.26329
Keywords:
Exploration, Four Umpak, Plane figures, Solid figures.

ABSTRACT
Ethnomathematics is a study that explains the relationship between culture and mathematical concepts . Plane figures has been taught in elementary school level and they are strengthened for junior high school students level, while solid figures are taught for junior high school students. Penataran Temple is a historical relic of three kingdoms namely Kediri, Singasari, and Majapahit. Penataran Temple is located in Penataran Village, Nglegok District, Blitar Regency, East Java Province. One of the buildings in Penataran Temple is the Four Umpak. In ancient era, Four Umpak in Penataran Temple was used as a place to gather, discuss and rest for the previous kings. This research is aimed to explore and describe the concept of plane and solid figures in the Empak Umpak building. Researchers used qualitative methode by an ethnographic approach. The object of research is the Four Umpak building and its ornaments. The data collection techniques used by observation, measurement, documentation, literature study, and some interviews. This research used data analysis techniques they are collecting data, reducing data, presenting data, and drawing conclusions, and verification. Checking the validity of the data using observation persistence and peer checking. The results showed that there are mathematical concepts in the Four Umpak building, namely the concept of plane and solid figures. The concept of plane figures found in the Four Umpak building are rectangles, isosceles trapezoids, and rhombus. While the concept of solid figures contained in the Penataran Temple building is a truncated rectangular pyramid and a rhombic prism.

*Corresponding author.
E-mail: ***faizal.chandra98@gmail.com***

How to cite: Chandra, F., Marhayati, & Nisa A.Z. (2024). exploration of plane and solid figures in four umpak buildings at penataran temple. *International Journal on Teaching and Learning Mathematics, VI*(2), 83-97.

1. INTRODUCTION

Exploration is an activity of extracting information from various relevant sources to gain new understanding of the object under study (Nisa & Rofiki, 2022; Syahrani, 2021). Meanwhile, culture according to Tylor in Chandra (2021) is a complex order that includes understanding, art, beliefs, laws, customs, morals, abilities, and habits acquired by humans as members of society. So that cultural exploration can be interpreted as an activity of extracting data related to a regional culture until a new understanding is obtained. One study that explores culture is

ethnomathematics.

The concept of culture-based mathematics is often called ethnomathematics (Hendriawan & Faridah, 2022; Hidayat et al., 2021). Ethnomathematics is the study of mathematics that includes culture, customs, or beliefs (Ambrosio, 1985; Begg, 2001). Ethnomathematics can be described as a bridge to learning mathematical ideas and concepts by modelling specific cultural activities (Auliya, 2021; Chandra, 2021). Thus it can be concluded that ethnomathematics is a study that explains the relationship between culture and mathematical concepts. One of the mathematical concepts that can be studied by ethnomathematics is plane and solid figures.

A plane figures is a two-dimensional geometry study with line segments as boundaries and has a perimeter and area. (Yuningsih et al., 2021). At the Junior High School (SMP) level, the material on plane figures is divided into two, namely triangles and rectangles taught in seven grade and circles taught in eight grade (Budiharjo, 2018; Chandra, 2021). Meanwhile, solid figures is a study of three-dimensional geometry that has a volume and has three core elements, namely vertex, planes, and Edge (Yuningsih et al., 2021). At the junior high school level, the material is divided into two, namely plane-sided solid figures taught in eight grade and curved-sided solid figures taught in nine grade (Budiharjo, 2018; Chandra, 2021). One of the cultural elements that can be connected to the material of plane and solid figures is the temple.

The temple is a building where the ashes of kings, and Hindu (Pandita) or Buddhist (monk or bhikkhu) priests and community worship in ancient times were stored, composed of a collection of stones (Kementrian Pedidikan dan Kebudayaan, 2016). East Java is one of the provinces that has the largest distribution of temple relics due to the many Hindu Buddhist kingdoms that stood there, one of which is Penataran Temple (Sedyawati et al., 2013). Penataran Temple is one of the historical relics of three kingdoms, namely Majapahit, Singasari, and Kediri Kingdoms. Penataran Temple is located in Penataran Village, Nglegok District, Blitar Regency, East Java Province (Munthahana & Budiarto, 2020; Susanti & Rahmadhani, 2021). The Penataran Temple complex consists of various buildings. Some of the buildings contained in the Panataran Temple, among others: Bale Agung, Four Umpak, Terrace Hall, Angkatahun Temple, Naga Temple, Main Temple, Palah Inscription, Perwara (Companion) Temple, and Partnership Pool. In the past, the Four Umpak in the penataran temple was used as a place to gather, discuss and rest for the previous kings (Chandra, 2021).

Munthahana and Budiarto's research (2020) obtained the results that there are mathematical concepts used in Penataran Temple, namely plane figures including polyhedrons and cuboids, numbers and symbols, and geometry transformations including translation and reflection. Furthermore, in the research of Wulandari and Budiarto (2020) obtained the results that there are mathematical concepts used in the architecture of the Singosari Kingdom heritage temple building, namely the concept of flat geometry including: triangles, squares, rhombuses, octagons, and circles and spatial shapes including cuboids and rectangular prisms. While Putri and Mariana's research (2022) obtained the results that there are mathematical concepts used in the Sumur Temple building, namely the concept of plane figures which include: squares, rectangles, trapezoids, parallelograms, and circles and solid figures buildings which include: cuboids, pyramids, and cylinder.

Differences with other research, especially Munthahana and Budiarto's research , which also conducted ethnomathematics research at the Penataran temple, are the focus study is Four Umpak building. The Four Umpak building has not been explored in depth on any research, even though based on direct observation and interviews with Penataran temple guards it was found related concepts of plane and solid figures. Furthermore, from the results of observations and

measurements of the Four Umpak building carried out by researchers with the help of colleagues on 29 December 2020, 6 February 2021, and 15 March 2021, objects were obtained that had a relationship to the concept of plane and solid figures. Based on the field data that has been collected, researchers conducted research with the title "Exploration of plane and solid figures in the Four Umpak Building at Penataran Temple" with the aim of finding the relationship between the Four Umpak building and flat and spatial building materials.

2. METHOD

The type of research used is qualitative research with an ethnographic approach that examines the relationship between a culture and the concept of plane and solid figures. Qualitative research is a descriptive research method and tends to use data analysis obtained from observations and measurements of the Four umpak building and supported by the results of interviews. The ethnographic approach is an approach that is carried out empirically and theoretically with the aim of obtaining descriptive results that analyse in-depth about culture based on intensive field observations. The ethnographic approach in this study is used to explore, analyse, describe, and explain the mathematical concepts on the plane and solid figures content contained in the Four Umpak.

The object of research is the Four Umpak building and its ornaments. The data collection techniques used are observation, measurement, documentation, literature study and interviews. The interviewee is Mr Agus, the guardian of the Penataran Temple cultural heritage preservation centre. Data analysis techniques used are data collection, data reduction, data presentation, conclusion drawing and verification. Checking the validity of the data using observation persistence and peer checking.

3. RESULTS AND DISCUSSION

Results In the front yard there are four stones located between the Terrace Hall and the main entrance of the Temple, the four stones are called Four Umpak. On the Four Umpak there is a relief that has the same style as the relief on the Main Temple, namely reliefs with Fauna patterns. Four Umpak functioned as a gathering place (discussion) and resting place for the previous kings and some researchers believe that this building used to be shaped like Pendopo Teras and Bale Agung, which has a batur. The four umpak are formed from andesite rocks that are block-shaped but conical upwards. On each umpak there are square ornaments with plain motifs. There are four stones on which the reliefs are placed as shown in Figure 1.

Figure 1. Four Umpak

The following are the results of an interview with the Penataran Temple Guard.

P : Berbentuk apakah bangunan Empat Umpak?
N : seperti kubus/balok tapi semakin mengkerucut keatas.
P : Apa fungsi dari Empat Umpak?
N : Tempat berkumpulnya dan istirahat para raja dahulu
P : Bagaimana sejarah dibangunnya Empat Umpak?
N : Dibangun pada 1269, sama seperti bale agung

P : Pada dinding umpak terdapat sebuah relief nggeh pak?
N : Iya mas terdapat relief seperti Candi Induk
P : Pada dinding umpak juga terdapat sebuah ornamen nggeh pak?
N : Iya mas, terdapat sebuah ornamen yang berbentuk bujur sangkar dengan motif polos

a. Umpak Building

The results of observations and measurements on the umpak and its ornaments show that the umpak building has four sides on each surface. An illustration of an umpak building can be seen in Figure 2.

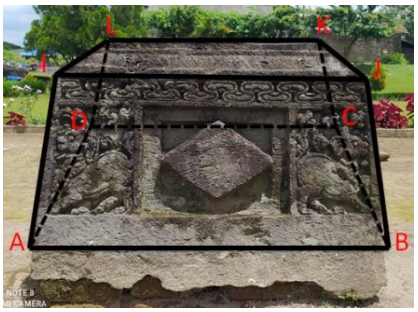

Figure 2. Umpak

Figure 2 shows that the four-sided flat ABJI is at the front, while the four-sided flat CDLK is at the back of the Umpak building. Furthermore, the four-sided flat IJKL is the top surface of the Umpak building, and the four-sided flat DAIL and BCKJ are on the left and right sides of the building respectively.

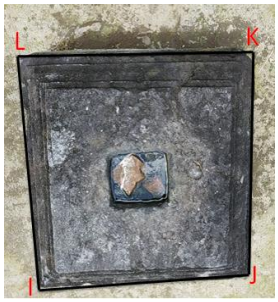

Figure 3a Umpak Top View

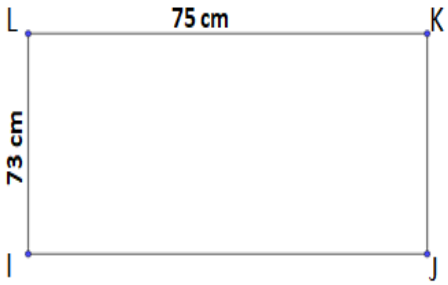

Figure 3b Four-sided Plane figures IJKL

Figures 3a and 3b show the four-sided flat IJKL which has 4 sides, namely $\overline{\text{LI}}$, $\overline{\text{JK}}$, $\overline{\text{IJ}}$, and $\overline{\text{KL}}$. The sides $\overline{\text{KL}}$ and $\overline{\text{IJ}}$ have a length of 75 cm. While the sides $\overline{\text{LI}}$ and $\overline{\text{JK}}$ has a length of 73 cm. The angles ∠IJK. ∠LIJ. ∠JKL. d*an* ∠KLI are each equal to 90°. From Figure 3a, a four-sided flat IJKL is obtained as an illustration of the top of the stone that forms Four Umpak. In the four-sided flat IJKL, the side lengths are $m\overline{\text{IJ}} = m\overline{\text{KL}} = 75$ cm. While the length of the side $m\overline{\text{JK}} = m\overline{\text{LI}} =$ 73 cm. The angle magnitude $m\angle\text{IJK} = m\angle\text{JKL} = m\angle\text{KLI} = m\angle\text{LIJ} = 90°$. Therefore, it can be concluded that the four-sided flat IJKL has two pairs of parallel sides of equal length and two pairs of equal angles, so it is called a rectangle. (Alexander & Koeberlein, 2014; Susanah & Hartono, 2014).

Figure 4a. Umpak Front View

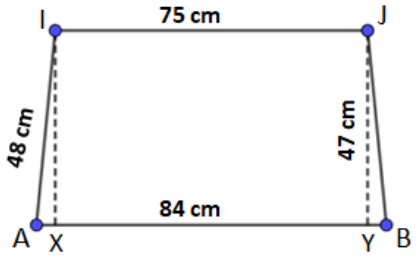

Figure 4b. Four-sided plane figures ABJI

Figures 4a and 4b show the four-sided flat ABJI which has 4 sides, namely $\overline{BJ}$, $\overline{AB}$, $\overline{IA}$. and $\overline{JI}$. The side $\overline{AB}$ has a length of 84 cm, while the $\overline{JI}$ has a length of 75 cm with $\overline{AB} \parallel \overline{JI}$. Side $\overline{IA}$ and $\overline{BJ}$ have a length of 48 cm. Angles ∠ABJ and ∠IAB are each equal to 85°. While the angles ∠JIA and ∠BJI are each equal to 95°. The height of the four-sided flat ABJI in Figure 4b can be measured from points $\overline{JY}$ and $\overline{IX}$ which has a length of 47 cm. It can be concluded that the four-sided flat ABJI has a pair of parallel sides that are not equal in length, a pair of hypotenuse that are equal in length, two pairs of equal angles, and the sum of all angles is 360°. Therefore, it can be concluded that the four-sided flat is a quadrilateral. (Alexander & Koeberlein, 2014; Susanah & Hartono, 2014). Furthermore, because it has a pair of parallel sides that are not equal in length, the four-sided flat can be categorised as a trapezoid (Alexander & Koeberlein, 2014; Susanah & Hartono, 2014). Meanwhile, because it has a pair of equal-length hypotenuse and two pairs of equal angles, the four-sided flat is categorised as an isosceles trapezoid (Alexander & Koeberlein, 2014; Susanah & Hartono, 2014). Therefore, it can be concluded that a four-sided flat that has these characteristics is an isosceles trapezoid (Alexander & Koeberlein, 2014; Susanah & Hartono, 2014)

Figure 5a. Umpak Left Side View

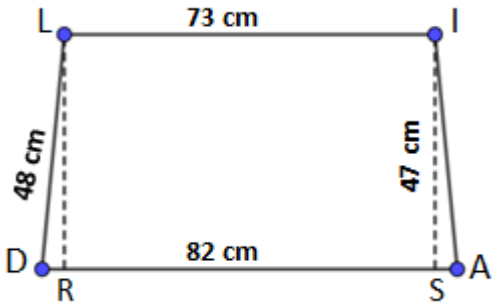

Figure 5b. Four-Sided Plane figures DAIL

Figures 5a and 5b show a DAIL flat that has 4 sides, namely $\overline{LD}$, $\overline{AI}$, $\overline{DA}$, and $\overline{IL}$. The side $\overline{DA}$ is 82 cm long, while side $\overline{IL}$ is 73 cm long. Side $\overline{LD}$ and $\overline{AI}$ have a length of 48 cm. Angles ∠DAI and ∠LDA is 85°. While the angles ∠ILD and ∠AIL by 95°. In Figure 5b, we can see the height of the four-sided flat DAIL measured from points $\overline{SI}$ and $\overline{RL}$ has a length of 47 cm. The DAIL four-sided plane figures has the same characteristics as the ABJI four-sided plane figures, therefore it can be concluded that the DAIL four-sided plane figures is an isosceles trapezoid.

International Journal on Teaching and Learning Mathematics
2020, Vol. xx, No. x, pp. xx-xx
P-ISSN: 2621-2188, E-ISSN: 2621-2196

Figure 6a. Umpak Right Side View

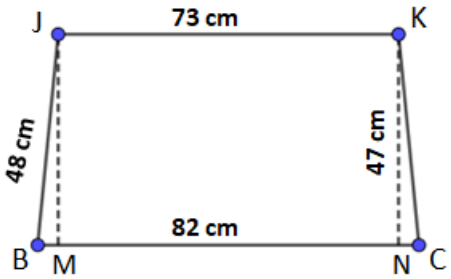

Figure 6b. Four-sided Plane figures BCKJ

Figures 6a and 6b show a BCKJ flat that has four sides, namely $\overline{BC}$, $\overline{JB}$, $\overline{CK}$, and $\overline{KJ}$. The side $\overline{BC}$ has a length of 82 cm. The side $\overline{JB}$ and $\overline{CK}$ have a length of 48 cm. While the side $\overline{KJ}$ has a length of 73 cm. Angles ∠BCK and ∠JBC are 85°. While the angles ∠KJB and ∠CKJ by 95°. Figure 6b also shows the height of the four-sided flat BCKJ characterised by the points $\overline{KN}$ and $\overline{JM}$ which has a length of 47 cm. The four-sided flat BCKJ has the same characteristics as the four-sided flat ABJI, therefore it can be concluded that the four-sided flat BCKJ is an isosceles trapezoid.

Figure 7a. Umpak Rear View

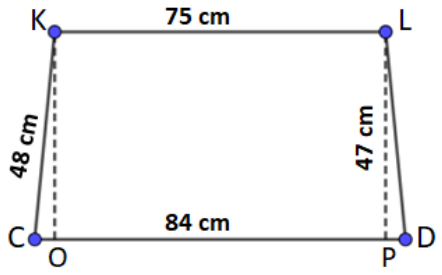

Figure 7b. Four-Sided Plane figures CDLK

Figures 7a and 7b show the plane figures CDLK which has 4 sides, namely $\overline{CD}$, $\overline{KC}$, $\overline{DL}$, and $\overline{LK}$. The side $\overline{CD}$ has a length of 84 cm. The side $\overline{LK}$ has a length of 75 cm. While the sides $\overline{KC}$ and $\overline{DL}$ have a length of 48 cm. The magnitude of ∠KCD and ∠CDL is 85°. While ∠LKC and ∠DLK have a magnitude of 95°. Figure 7b shows the height of the plane figures CDLK that is point $\overline{PL}$ and $\overline{OK}$ which has a length of 47 cm. The four-sided plane figures CDLK has the same characteristics as the four-sided plane figures ABJI, therefore it can be concluded that the four-sided plane figures CDLK is an isosceles trapezoid.

Table 1 summarises the results of the measurements taken on the four-sided plane figures ABJI, IJKL, CDLK, DAIL and BCKJ.

Table 1. Measurement Results of Four-Sided Umpak Plane figures

No.	Four-Sided Plane figures	Measurement Results		
		Many Sides	Side Length	Large Angle
1	Four-sided Plane figures ABJI	4 ($\overline{AB}$, $\overline{BJ}$, $\overline{JI}$, and $\overline{IA}$)	m$\overline{AB}$ = 84 cm m$\overline{JI}$ = 75 cm m$\overline{BJ}$ = 48 cm m$\overline{IA}$ = 48 cm	m∠IAB = 85° m∠ABJ = 85° m∠BJI = 95° m∠JIA = 95°
2	Four Sided Plane	4 ($\overline{IJ}$, $\overline{JK}$, $\overline{KL}$,	m$\overline{IJ}$ = 75 cm	m∠IJK = 90°

	figures IJKL		and $\overline{LI}$)	m$\overline{KL}$ = 75 cm m$\overline{JK}$ = 73 cm m$\overline{LI}$ = 73 cm	m∠JKL = 90° m∠KLI = 90° m∠LIJ = 90°
3	Four-Sided figures CDLK	Plane	4 ($\overline{CD}$, $\overline{DL}$, $\overline{LK}$, and $\overline{KC}$)	m$\overline{CD}$ = 84 cm m$\overline{LK}$ = 75 cm m$\overline{DL}$ = 48 cm m$\overline{KC}$ = 48 cm	m∠CDL = 85° m∠KCD = 85° m∠DLK = 95° m∠LKC = 95°
4	Four-Sided figures BCKJ	Plane	4 ($\overline{BC}$, $\overline{CK}$, $\overline{KJ}$, and $\overline{JB}$)	m$\overline{BC}$ = 82 cm m$\overline{KJ}$ = 73 cm m$\overline{CK}$ = 48 cm m$\overline{JB}$ = 48 cm	m∠JBC = 85° m∠BCK = 85° m∠CKJ = 95° m∠KJB = 95°
5	Four-Sided figures DAIL	Plane	4 ($\overline{DA}$, $\overline{AI}$, $\overline{IL}$, and $\overline{LD}$)	m$\overline{DA}$ = 82 cm m$\overline{IL}$ = 73 cm m$\overline{AI}$ = 48 cm m$\overline{LD}$ = 48 cm	m∠LDA = 85° m∠DAI = 85° m∠AIL = 95° m∠ILD = 95°

Thus, based on the explanation of the four-sided plane figures in the Umpak building depicted in Figure 2, the ABCD.IJKL building has six four-sided plane figures, namely ABCD, IJKL, BCKJ, DAIL, ABJI, and CDLK. The building has eight vertex, namely A, B, C, D, I, J, K, and L, and has 12 Edge, namely $\overline{AB}$, $\overline{CD}$, $\overline{BC}$, $\overline{DA}$, $\overline{IJ}$, $\overline{KL}$, $\overline{JK}$, $\overline{LI}$, $\overline{IA}$, $\overline{DL}$, $\overline{BJ}$, and $\overline{CK}$. Edge $\overline{CD}$ and $\overline{AB}$ are 84 cm long. Edge $\overline{DA}$ and $\overline{BC}$ have a length of 82 cm. Edge $\overline{IJ}$ and $\overline{KL}$ have a length of 75 cm. Edge $\overline{LI}$ and $\overline{JK}$ have a length of 73 cm. Edge $\overline{IA}$, $\overline{DL}$, $\overline{BJ}$, and $\overline{CK}$ have a length of 48 cm. The solid figures ABCD.IJKL is presented in Figure 8.

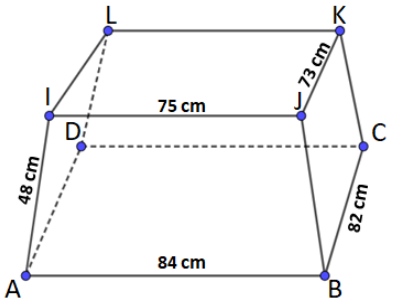

Figure 8. Constructing the solid figures ABCD.IJKL

Figure 8 shows the solid figures ABCD.IJKL has 12 Edge, namely $\overline{AB}$, $\overline{BC}$, $\overline{CD}$, $\overline{DA}$, $\overline{IJ}$, $\overline{JK}$, $\overline{KL}$, $\overline{LI}$, $\overline{IA}$, $\overline{BJ}$, $\overline{CK}$, and $\overline{DL}$ and 6 planes namely ABCD, IJKL, BCKJ, ADLI, ABJI, and CDLK. Table 1 it is known that the length of Edge $m\overline{AB} = m\overline{CD} = 84\ cm$, $m\overline{BC} = m\overline{DA} = 82\ cm$, $m\overline{IJ} = m\overline{KL} = 75\ cm$, $m\overline{JK} = m\overline{LI} = 73\ cm$, and $m\overline{IA} = m\overline{BJ} = m\overline{CK} = m\overline{DL} = 48$ cm. Because $\overline{AB} \cong \overline{CD}$, $\overline{BC} \cong \overline{DA}$, $\overline{IJ} \cong \overline{KL}$, $\overline{JK} \cong \overline{LI}$, and $\overline{IA} \cong \overline{BJ} \cong \overline{CK} \cong \overline{DL}$, then it can be said that the four-sided plane figures ABCD and IJKL are parallel but not equal as well as $ADLI \cong BCKJ$ and $ABJI \cong CDLK$. In Table 1 it is known that $ABCD \cong IJKL$. Because the four-sided plane figures ABCD and IJKL fulfil the same characteristics, it can be said that ABCD and IJKL are rectangles. In Table 1, it is known that $ADLI \cong BCKJ$ and $ABJI \cong CDLK$. It can be concluded that BCKJ, ADLI, ABJI, and CDLK are isosceles trapezoids. Therefore, it can be

International Journal on Teaching and Learning Mathematics
2020, Vol. xx, No. x, pp. xx-xx
P-ISSN: 2621-2188, E-ISSN: 2621-2196

concluded that the solid figures ABCD.IJKL has 8 corners, 12 Edge, and 6 planes. The six planes consist of 2 parallel rectangular planes and 4 parallel trapezoidal planes. Therefore, it can be concluded that the solid figures ABCD.IJKL is a truncated rectangular pyramid. (Alexander & Koeberlein, 2014; Susanah & Hartono, 2014).

b. Ornament on Umpak

From observations and measurements of the ornaments on the Umpak front and right side, it can be seen that there are ornaments that have four sides on each surface. These ornaments can be seen in Figures 9a and 4.24b.

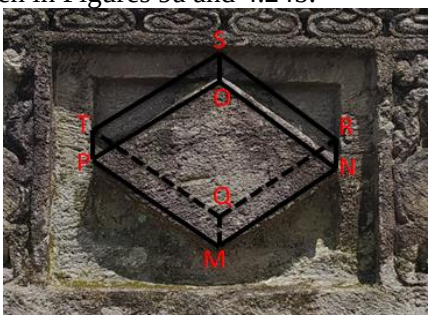

Figure 9a. Ornament on Umpak Front View

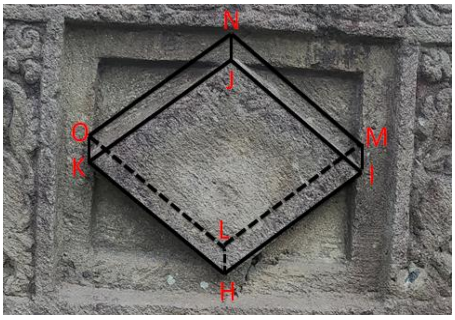

Figure 9b. Ornament on Umpak Right Side View

Figures 9a and 9b show the ornaments on the Umpak in front and right side views, where the four-sided flat MNOP is the front side of the ornaments on the Umpak in front view, and the four-sided flat HIJK is the front side of the ornaments on the Umpak in right side view.

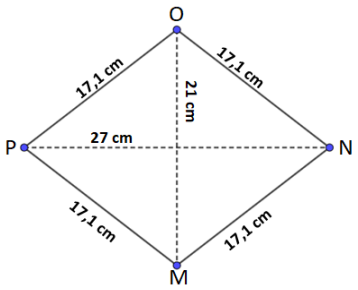

Figure 10. Four-sided plane figures MNOP

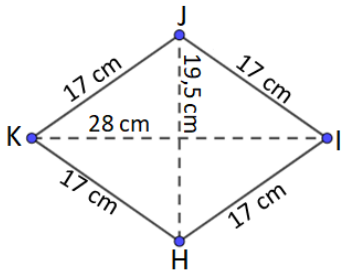

Figure 11. Four-sided Plane figures HIJK

Figure 10 shows a four-sided plane figures MNOP has 4 sides, namely $\overline{\text{MN}}$, $\overline{\text{NO}}$, $\overline{\text{OP}}$, and $\overline{\text{PM}}$. The length of the sides $\overline{\text{MN}}$, $\overline{\text{NO}}$, $\overline{\text{OP}}$, and $\overline{\text{PM}}$ is 17.1 cm. The angle magnitudes $\angle\text{OPM}$ and $\angle\text{MNO}$ is 76°. While the magnitude of the angles $\angle\text{PMN}$ and $\angle\text{NOP}$ is 104°. Figure 10 shows the bisector connecting points M with O and P with N. The length of the bisector is 27 cm. $\overline{\text{NP}}$ is 27 cm, while the length of the line $\overline{\text{MO}}$ 21 cm. The length of the side $m\overline{\text{MN}} = m\overline{\text{NO}} = m\overline{\text{OP}} = m\overline{\text{PM}} = 17.1\ cm$. Large $m\angle\text{OPM} = m\angle\text{MNO} = 76°$. While large $m\angle\text{PMN} = m\angle\text{NOP} = 104°$. There is a line connecting points M with O and P with N in Figure 10. $\overline{NP}$ has a length of 27 cm and the line $\overline{MO}$ has a length of 21 cm with point B as the meeting point between the line $\overline{NP}$ with $\overline{MO}$. $\overline{NP}$ is a diagonal that divides the four-sided plane figures of MNOP horizontally, while $\overline{MO}$ is a diagonal that divides the four-sided flat MNOP vertically. Thus, it can be concluded that the four-sided flat MNOP has four equal-length sides, two pairs of equal angles, and two diagonals that divide MNOP vertically and horizontally. Therefore, it can be concluded

International Journal on Teaching and Learning Mathematics
2020, Vol. xx, No. x, pp. xx-xx
P-ISSN: 2621-2188, E-ISSN: 2621-2196

that the four-sided plane figures of MNOP is a rhombus. (Alexander & Koeberlein, 2014; Susanah & Hartono, 2014). This finding is in line with the results of researcher interviews with informants who stated that the ornaments on Umpak are rectangular.

Figure 11 shows a four-sided flat HIJK has 4 sides, namely $\overline{HI}$, $\overline{IJ}$, $\overline{JK}$, and $\overline{KH}$. The sides $\overline{HI}$, $\overline{IJ}$, $\overline{JK}$, and $\overline{KH}$ have a length of 17 cm. The angle magnitudes ∠HIJ and ∠JKH is 70°. While the magnitude of the angles ∠IJK and ∠KHI is 110°. Figure 8 shows the bisector connecting points H with J and I with K. The bisector has a length of 19.5 cm. $\overline{HJ}$ has a length of 19.5 cm, while the line $\overline{IK}$ has a length of 21 cm. The four-sided plane figures HIJK has the same characteristics as the four-sided plane figures MNOP, therefore it can be concluded that the four-sided plane figures CDLK is a rhombus

The ornaments on the front Umpak have four side surfaces in the form of four-sided plane figures as presented in Figure 12.

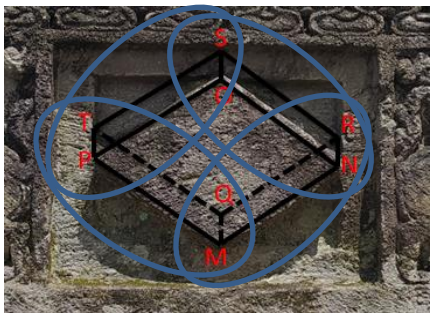

Figure 12. Four Side Surfaces of a Front View Umpak Ornament in the Shape of a Four-Sided Plane figures

There are four side surfaces of the ornament, and each surface is a four-sided plane figures named MNRQ, ONRS, POST, and PMQT. The four four-sided plane figures can be seen in Figures 13, 14, 15, and 16.

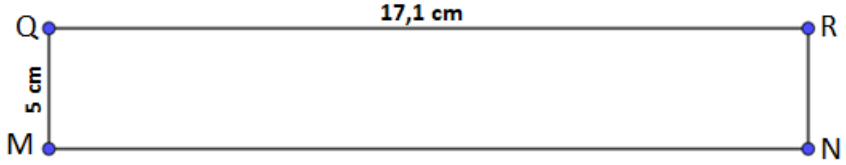

Figure 13. MNRQ Four-Sided Plane figures

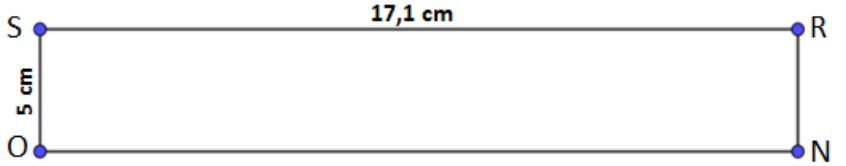

Figure 14. ONRS Four-Sided Plane figures

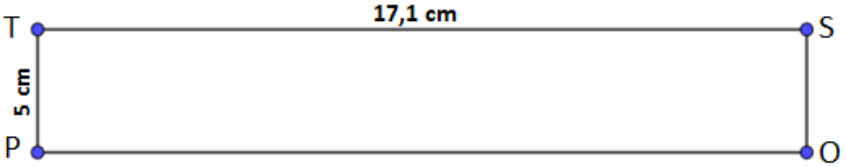

Figure 15. Four-Sided Plane figures POST

International Journal on Teaching and Learning Mathematics
2020, Vol. xx, No. x, pp. xx-xx
P-ISSN: 2621-2188, E-ISSN: 2621-2196

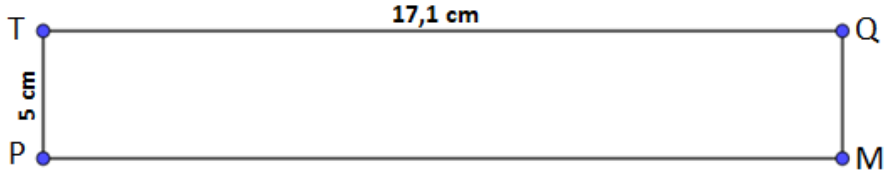

Figure 16. PMQT Four-Sided Plane figures

Figure 13 shows that the plane figures MNRQ has 4 sides, namely $\overline{MN}$, $\overline{RQ}$, $\overline{QM}$, $\overline{NR}$. The sides $\overline{RQ}$ and $\overline{MN}$ are 17.1 cm long. Side $\overline{QM}$ and $\overline{NR}$ has a length of 5 cm. The magnitude of $\angle MNR$. $\angle QMN$. $\angle NRQ$. dan $\angle RQM$ is 90°. Figure 14 shows that the flat ONRS has 4 sides, namely $\overline{ON}$, $\overline{RS}$, $\overline{SO}$, and $\overline{NR}$. The sides $\overline{RS}$ and $\overline{ON}$ are 17.1 cm long. Side $\overline{SO}$ and $\overline{NR}$ has a length of 5 cm. The magnitude of $\angle ONR$. $\angle SON$. $\angle NRS$. dan $\angle RSO$ is 90°. Figure 15 shows that the POST plane figures has 4 sides, namely $\overline{PO}$, $\overline{ST}$, $\overline{TP}$, and $\overline{OS}$. The sides $\overline{ST}$ and $\overline{PO}$ are 17.1 cm long. Side $\overline{TP}$ and $\overline{OS}$ has a length of 5 cm. The magnitude of $\angle POS$. $\angle TPO$. $\angle OST$. dan $\angle STP$ is 90°. Figure 16 shows that the PMQT plane figures has 4 sides, namely $\overline{PM}$, $\overline{QT}$, $\overline{TP}$ and $\overline{MQ}$. The sides $\overline{QT}$ and $\overline{PM}$ are 17.1 cm long. Side $\overline{TP}$ and $\overline{MQ}$ has a length of 5 cm. The magnitude of $\angle PMQ$. $\angle TPM$. $\angle MQT$. dan $\angle QTP$ is 90°. Therefore, it can be concluded that the four-sided flat MNRQ, ONRS, POST, and PMQT has two pairs of parallel sides of equal length and two pairs of equal angles, so it is called a rectangle. (Alexander & Koeberlein, 2014; Susanah & Hartono, 2014).

The ornaments on the right side of the Umpak have four side surfaces in the form of four-sided plane figures, as seen in Figure 17.

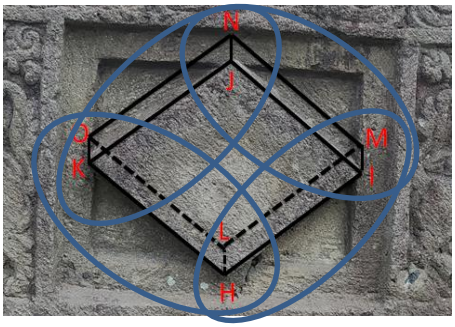

Figure 17. Four Side Surfaces of an Umpak Ornament Looking Right Side Shaped as a Four-Sided Plane figures

Based on Figure 17, it can be seen that the ornaments on the Umpak right side view have four side surfaces that form a four-sided plane figures. These surfaces are known as JIMN, KJNO, KHLO, and HIML, presented in Figures 18, 19, 20, and 21.

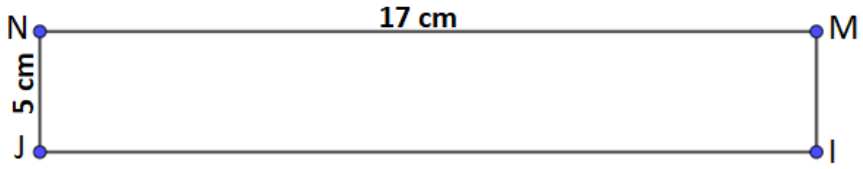

Figure 18. JIMN Four-Sided Plane figures

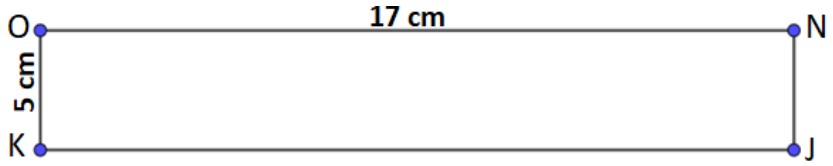

Figure 19. KJNO Four-Sided Plane figures

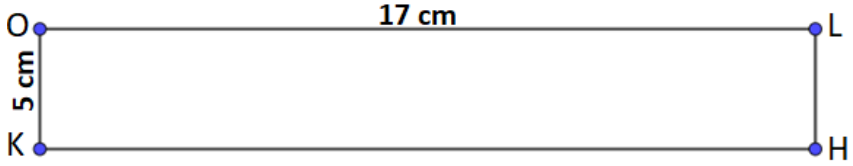

Figure 20. KHLO Four-Sided Plane figures

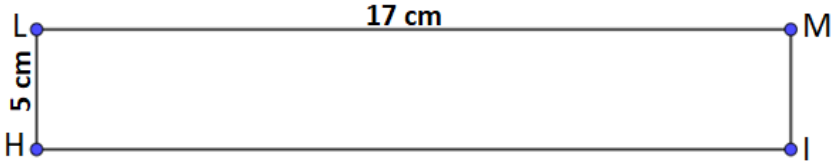

Figure 21. HIML Four-sided plane figures

Figure 18 shows that the plane figures JIMN has 4 sides, namely $\overline{JI}$, $\overline{MN}$, $\overline{NJ}$, and $\overline{IM}$. The sides $\overline{MN}$ and $\overline{JI}$ are 17 cm long, while the sides $\overline{NJ}$ and $\overline{IM}$ are 5 cm long. The magnitude of ∠JIM. ∠IMN. ∠MNJ. ∠NJI is 90°. Figure 19 shows that the plane figures KJNO has 4 sides, namely $\overline{KJ}$, $\overline{NO}$, $\overline{JN}$, and $\overline{OK}$. The sides $\overline{NO}$ and $\overline{KJ}$ are 17 cm long, while the sides $\overline{OK}$ and $\overline{JN}$ are 5 cm long. The magnitude of ∠KJN. ∠JNO. ∠NOK. ∠OKJ is 90°. Figure 20 shows that the plane figures KHLO has 4 sides, namely $\overline{KH}$, $\overline{LO}$, $\overline{HL}$, and $\overline{OK}$. The sides $\overline{LO}$ and $\overline{KH}$ are 17 cm long, while the sides $\overline{OK}$ and $\overline{HL}$ are 5 cm long. The magnitude of ∠KHL. ∠HLO. ∠LOK. ∠OKH is 90°. Figure 21 shows that the HIML plane figures has 4 sides, namely $\overline{HI}$, $\overline{ML}$, $\overline{IM}$, and $\overline{LH}$. The sides $\overline{ML}$ and $\overline{HI}$ have a length of 17 cm, while the sides $\overline{LH}$ and $\overline{IM}$ are 5 cm long. The magnitude of ∠HIM. ∠IML. ∠MLH. ∠LHI is 90°. Therefore, it can be concluded that the four-sided flat JIMN, KJNO, KHLO, and HIML has two pairs of parallel sides of equal length and two pairs of equal angles, so it is called a rectangle. (Alexander & Koeberlein, 2014; Susanah & Hartono, 2014).

Table 2 summarises the measurement results found on the four-sided plane figures MNOP, HIJK, MNRQ, ONRS, POST, PMQT, JIMN, KJNO, KHLO and HIML.

Table 2 Measurement Results of Four-Sided Plane figures Ornaments on Umpak

No.	Four-Sided Plane figures	Measurement Results		
		Many Sides	Side Length	Large Angle
1	2	3	4	5
1	Four Sided Plane figures MNOP	4 ($\overline{MN}$, $\overline{NO}$, $\overline{OP}$, and $\overline{PM}$)	m$\overline{MN}$ = 17.1 cm m$\overline{NO}$ = 17.1 cm m$\overline{OP}$ = 17.1 cm m$\overline{PM}$ = 17.1 cm	m∠MNO = 76° m∠OPM = 76° m∠NOP = 104° m∠PMN = 104°
2	HIJK Four-Sided Plane figures	4 ($\overline{HI}$, $\overline{IJ}$, $\overline{JK}$, and $\overline{KH}$)	m$\overline{HI}$ = 17 cm m$\overline{IJ}$ = 17 cm m$\overline{JK}$ = 17 cm m$\overline{KH}$ = 17 cm	m∠HIJ = 70° m∠JKH = 70° m∠IJK = 110° m∠KHI = 110°

3	MNRQ Four-Sided Plane figures	4 ($\overline{MN}$, $\overline{NR}$, $\overline{RQ}$, and $\overline{QM}$)	m$\overline{MN}$ = 17.1 cm m$\overline{RQ}$ = 17.1 cm m$\overline{NR}$ = 5 cm m$\overline{QM}$ = 5 cm	m∠MNR = 90° m∠NRQ = 90° m∠RQM = 90° m∠QMN = 90°
4	ONRS Four-Sided Plane figures	4 ($\overline{ON}$, $\overline{NR}$, $\overline{RS}$, and $\overline{SO}$)	m$\overline{ON}$ = 17.1 cm m$\overline{RS}$ = 17.1 cm m$\overline{NR}$ = 5 cm m$\overline{SO}$ = 5 cm	m∠ONR = 90° m∠NRS = 90° m∠RSO = 90° m∠SON = 90°
5	Four-Sided Plane figures POST	4 ($\overline{PO}$, $\overline{OS}$, $\overline{ST}$, and $\overline{TP}$)	m$\overline{PO}$ = 17.1 cm m$\overline{ST}$ = 17.1 cm m$\overline{OS}$ = 5 cm m$\overline{TP}$ = 5 cm	m∠POS = 90° m∠OST = 90° m∠STP = 90° m∠TPO = 90°
6	PMQT Four-Sided Plane figures	4 ($\overline{PM}$, $\overline{MQ}$, $\overline{QT}$, and $\overline{TP}$)	m$\overline{PM}$ = 17.1 cm m$\overline{QT}$ = 17.1 cm m$\overline{MQ}$ = 5 cm m$\overline{TP}$ = 5 cm	m∠PMQ = 90° m∠MQT = 90° m∠QTP = 90° m∠TPM = 90°
7	Four-Sided Plane figures JIMN	4 ($\overline{JI}$, $\overline{IM}$, $\overline{MN}$, and $\overline{NJ}$)	m$\overline{JI}$ = 17 cm m$\overline{MN}$ = 17 cm m$\overline{IM}$ = 5 cm m$\overline{NJ}$ = 5 cm	m∠JIM = 90° m∠IMN = 90° m∠MNJ = 90° m∠NJI = 90°
8	Four-Sided Plane figures KJNO	4 ($\overline{KJ}$, $\overline{JN}$, $\overline{NO}$, and $\overline{OK}$)	m$\overline{KJ}$ = 17 cm m$\overline{NO}$ = 17 cm m$\overline{JN}$ = 5 cm m$\overline{OK}$ = 5 cm	m∠KJN = 90° m∠JNO = 90° m∠NOK = 90° m∠OKJ = 90°
9	KHLO Four-Sided Plane figures	4 ($\overline{KH}$, $\overline{HL}$, $\overline{LO}$, and $\overline{OK}$)	m$\overline{KH}$ = 17 cm m$\overline{LO}$ = 17 cm m$\overline{HL}$ = 5 cm m$\overline{OK}$ = 5 cm	m∠KHL = 90° m∠HLO = 90° m∠LOK = 90° m∠OKH = 90°
10	HIML Four-Sided Plane figures	4 ($\overline{HI}$, $\overline{IM}$, $\overline{ML}$, and $\overline{LH}$)	m$\overline{HI}$ = 17 cm m$\overline{ML}$ = 17 cm m$\overline{IM}$ = 5 cm m$\overline{LH}$ = 5 cm	m∠HIM = 90° m∠IML = 90° m∠MLH = 90° m∠LHI = 90°

The MNOP.QRST building produced by the front view Umpak ornament has 6 four-sided flat planes, namely MNOP, MNRQ, QRST, ONRS, PMQT, and POST, and has 8 vertex namely T, S, R, Q, P, O, N, and M. In addition, there are also 12 Edge, namely $\overline{MN}$, $\overline{OP}$, $\overline{NO}$, $\overline{PM}$, $\overline{RS}$, $\overline{QR}$, $\overline{TQ}$, $\overline{ST}$, $\overline{QM}$, $\overline{TP}$. $\overline{NR}$, and $\overline{OS}$. Edge $\overline{MN}$, $\overline{OP}$, $\overline{NO}$, $\overline{PM}$, $\overline{RS}$, $\overline{QR}$, $\overline{ST}$, and $\overline{TQ}$ has a length of 17.1 cm. While the length of the Edge $\overline{QM}$, $\overline{OS}$, $\overline{NR}$, and $\overline{TP}$ have a length of 5 cm. The construction of MNOP.QRST is shown in Figure 22.

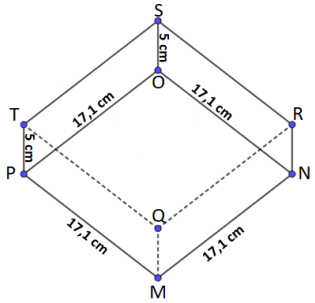

Figure 22. Constructing solid figures MNOP.QRST

International Journal on Teaching and Learning Mathematics
2020, Vol. xx, No. x, pp. xx-xx
P-ISSN: 2621-2188, E-ISSN: 2621-2196

Figure 22 shows the solid figures MNOP.QRST has 12 Edge, $\overline{\text{MN}}$, $\overline{\text{OP}}$, $\overline{\text{NO}}$, $\overline{\text{PM}}$, $\overline{\text{RS}}$, $\overline{\text{QR}}$, $\overline{\text{TQ}}$, $\overline{\text{ST}}$, $\overline{\text{QM}}$, $\overline{\text{TP}}$, $\overline{\text{NR}}$, and $\overline{\text{OS}}$ and 6 planes namely MNOP, MNRQ, QRST, ONRS, PMQT, and POST. Table 1 it is known that the length of Edge $\overline{\text{MN}} = \overline{\text{NO}} = \overline{\text{OP}} = \overline{\text{PM}} = \overline{\text{QR}} = \overline{\text{RS}} = \overline{\text{ST}} = \overline{\text{TQ}} = 17,1\ cm$ and $\overline{QM} = \overline{NR} = \overline{OS} = \overline{TP} = 5$ cm. Because $\overline{\text{MN}} = \overline{\text{NO}} = \overline{\text{OP}} = \overline{\text{PM}} = \overline{\text{QR}} = \overline{\text{RS}} = \overline{\text{ST}} = \overline{\text{TQ}}$ and $\overline{QM} = \overline{NR} = \overline{OS} = \overline{TP}$, it can be concluded that the $MNOP = QRST$ and $MNRQ = ONRS = POST = PMQT$. In Table 2 it is known that $MNOP \cong QRST$. Because the four-sided plane figures MNOP and QRST fulfil the same characteristics, it can be said that MNOP and QRST are rhombus. In Table 2, it is known that $MNRQ \cong ONRS \cong PMQT \cong POST$. It can be concluded that MNRQ, ONRS, PMQT, dan POST are a rectangle. Therefore, it can be concluded that the solid figures MNOP.QRST has 8 corners, 12 Edge, and 6 planes. The six planes consists of 2 parallel and equal-length rhombus planes and 4 parallel and equal-length rectangular planes. Therefore, it can be concluded that the MNOP.QRST is a rhombic prism. (Alexander & Koeberlein, 2014; Susanah & Hartono, 2014).

Based on the description of the four-sided plane figures on the ornaments in Umpak looking right side, HIJK.LMNO has 6 four-sided plane figures, namely HIJK, LMNO, JIMN, KJNO, KHLO, and HIML. It also has 8 vertex O, N, M, L, K, J, I, and H and 12 Edge, namely $\overline{\text{HI}}$, $\overline{\text{IJ}}$, $\overline{\text{JK}}$, $\overline{\text{KH}}$, $\overline{\text{LM}}$, $\overline{\text{MN}}$, $\overline{\text{NO}}$, $\overline{\text{OL}}$, $\overline{\text{HL}}$, $\overline{\text{IM}}$, $\overline{\text{JN}}$, and $\overline{\text{KO}}$. Edge $\overline{\text{HI}}$, $\overline{\text{IJ}}$, $\overline{\text{JK}}$, $\overline{\text{KH}}$, $\overline{\text{LM}}$, $\overline{\text{MN}}$, $\overline{\text{NO}}$, and $\overline{\text{OL}}$ have a length of 17 cm, while the Edge $\overline{\text{HL}}$, $\overline{\text{IM}}$, $\overline{\text{JN}}$, and $\overline{\text{KO}}$ have a length of 5 cm. This solid figures can be seen in Figure 23.

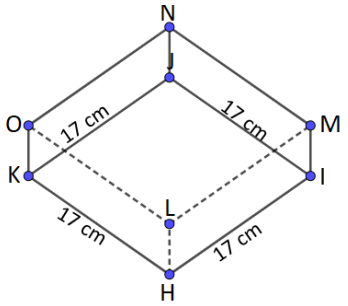

Figure 23. Buildings HIJK.LMNO

Figure 23 shows the solid figures HIJK.LMNO has 12 Edge, $\overline{\text{HI}}$, $\overline{\text{IJ}}$, $\overline{\text{JK}}$, $\overline{\text{KH}}$, $\overline{\text{LM}}$, $\overline{\text{MN}}$, $\overline{\text{NO}}$, $\overline{\text{OL}}$, $\overline{\text{HL}}$, $\overline{\text{IM}}$, $\overline{\text{JN}}$, and $\overline{\text{KO}}$ and 6 planes namely HIJK, LMNO, JIMN, KJNO, KHLO, and HIML. Table 1 it is known that the length of Edge $\overline{\text{HI}} = \overline{\text{IJ}} = \overline{\text{JK}} = \overline{\text{KH}} = \overline{\text{LM}} = \overline{\text{MN}} = \overline{\text{NO}} = \overline{\text{OL}} = 17\ cm$ and $\overline{\text{HL}} = \overline{\text{IM}} = \overline{\text{JN}} = \overline{\text{KO}} = 5\ cm$. Because Edge $\overline{\text{HI}} = \overline{\text{IJ}} = \overline{\text{JK}} = \overline{\text{KH}} = \overline{\text{LM}} = \overline{\text{MN}} = \overline{\text{NO}} = \overline{\text{OL}}$ and $\overline{\text{HL}} = \overline{\text{IM}} = \overline{\text{JN}} = \overline{\text{KO}}$, it can be concluded that the $HIJK = LMNO\ dan\ JIMN = KJNO = KHLO = HIML$. In Table 2 it is known that $HIJK \cong LMNO$. Because the four-sided plane figures HIJK and LMNO fulfil the same characteristics, it can be said that HIJK and LMNO are rhombus. In Table 2, it is known that $JIMN \cong KJNO \cong KHLO \cong HIMNL$. It can be concluded that JIMN, KJNO, KHLO, and HIML are a rectangle. Therefore, it can be concluded that the solid figures HIJK.LMNO has 8 corners, 12 Edge, and 6 planes. The six planes consists of 2 parallel and equal-length rhombus planes and 4 parallel and equal-length

rectangular planes. Therefore, it can be concluded that the HIJK.LMNO is a rhombic prism. (Alexander & Koeberlein, 2014; Susanah & Hartono, 2014).

4. CONCLUSION

Based on the results of research and discussion, it can be concluded that there are concepts of plane and solid figures in the building of Four Umpak Penataran Temple as follows:

1. The concept of plane figures found in the building of Four Umpak Penataran Temple is nine rectangle, four isosceles trapezoid, and two rhombus.
2. The concept of solid figures contained in the building of the Four Umpak Penataran Temple is one truncated rectangular pyramid and two rhombic prism.

REFERENCES

Alexander, D. C., & Koeberlein, G. M. (2014). *Elementary geometry for college students*. Cengage Learning.

Ambrosio, U. D. (1985). Ethnomathematics and its Place in the History and Pedagogy of Mathematics. *For the Learning of Mathematics*, *5*(1), 44–48.

Auliya', A. N. (2021). *Exploration of Flat Buildings and Geometric Transformations in Batik Pamiluto Motifs of Ceplokan Gresik* (p. 6). Maulana Malik Ibrahim State Islamic University.

Begg, A. (2001). Ethnomathematik: Warum, und was weiter? *ZDM, 33*, 71-74.

Chandra, F. (2021). Exploration of flat and spatial shapes in the Penataran Temple building in Blitar Regency. *Thesis.* http://etheses.uin-malang.ac.id/34042/

D'Ambrosio, U. (1985). Ethnomathematics and Its Place in the History and Pedagogy of Mathematics. *For the Learning of Mathematics, 5* (February 1985), 44-48 (in 'Classics').

Hendriawan, P., & Faridah, S. (2022). Exploration of Ethnomathematics in Bekles Traditional Game. *Journal of Tadris Matematika*, *5*(2), 149-158.

Hidayat, T., Asmar, A., & Yerizon. (2021). Exploration of Ethnomathematics *at Muara Takus Temple in Koto Kampar Riau*. *5*.

Kementrian Pedidikan dan Kebudayaan. (2016). *Kamus Besar Bahasa Indonesia*. Kementerian Pendidikan Dan Kebudayaan Republik Indonesia.

Munthahana, J., & Budiarto, M. T. (2020). Ethnomathematics Exploration in Panataran Temple and Its Implementation in Learning. *Indonesian Journal of Science and Mathematics Education*, *3*(2), 196-209.

Nisa, A. Z., & Rofiki, I. (2022). Exploration of the Ethnomathematics of the Bung Karno Tomb Complex in Cultural Based Mathematics Learning. *Journal of Medives: Journal of Mathematics ...*, *6*(1), 107-120. https://e-journal.ivet.ac.id/index.php/matematika/article/view/1926%0Ahttps://e-journal.ivet.ac.id/index.php/matematika/article/download/1926/1433

Putri, N. N. P., & Mariana, N. (2022). Ethnomathematics in Sumus Temple as Geometry Concept in Elementary School. *Journal of Elementary School Teacher Education, 10*(2), 289-301.

Sedyawati, E., Santiko, H., Djafar, H., Maulana, R., Ramelan, W. D. S., & Ashari, C. (2013). *Indonesian temples: Java Series: Indonesian-English* (Vol. 1). Directorate General of Culture.

Susanah, H. (2014). *Geometry*. Unesa University Press. Surabaya.

Susanti, E., & Rahmadhani, A. P. (2021). *Concept of Geometry in Penataran Temple*. *5*(1), 58–65.

Syahrani, A. (2021). *Exploration of congruence and similarity in Karo traditional house ornaments*. Maulana Malik Ibrahim State Islamic University. http://etheses.uin-malang.ac.id/id/eprint/34133

Wulandari, D., & Budiarto, M. T. (2020). Ethnomathematics: An Exploration of Singosari Kingdom Artefacts. *Transformation: Journal of Mathematics and Mathematics Education*, *4*(1), 203-217.

Yuningsih, N., Nursuprianah, I., & Benefits, B. (2021). Exploration of Ethnomathematics in the Design of the Lengkong Traditional House. *Jakarta Journal of Mathematics Education Research*, *3*(1), 1-13. https://doi.org/10.21009/jrpmj.v3i1.19517