Development of Geometric Shape Wood Joint Technique Into the Creation of Thai Lanna Teak Furniture with An Environmentally Friendly Process in Thailand

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Abstract

Teak cuttings and young teak trees are cut to expand the rows in teak plantations. This expansion is related to economically improving cultivated areas; farmers will eliminate this waste by burning or cutting them down and making charcoal, significantly impacting the environment. This research aims to develop a process of using split teak to develop a technique for wood doweling with geometric patterns, especially for use in the production of antique Thai furniture to create sustainability as these details: 1) Way of Life, 2) Economy and 3) Environment, which involves research to help create a development model. Then, it gains community sustainability, and this research will test the strength of the teak by using force techniques: 1) Baking and 2) Soaking the wood in water and relying on sunlight. These techniques found that both forms had similar shear strength values and could be applied to the two types of developed wooden dowels with six geometrical shapes. Moreover, the wooden dowels with the highest shear strengths consisted of 1) Hexagonal Dowels, 2) Square Dowels, and 3) Circular Dowels. Similarly, the three types of dowels were used to select the suitable doweling pattern for producing traditional Thai furniture by using the Cross-impact matrix principle (n=20), and it was found that the square dowel from soaked wood before drying in the sun had the most suitable value, (91.67). It was used to form a dowel for producing dismantlable antique Thai furniture. In the same way, when analyzing consumer satisfaction (n=254), using simple random sampling (Simple Random Sampling) at a confidence level of 90% from three aspects of assessment: 1) Aesthetic, 2) Functional, 3) Symbolic, and it was found that the Model Summary Test Value of Consumer Satisfaction was 80.5 %. Therefore, all three factors were applied to predict the needs and behaviors of consumers toward antique Thai furniture produced by the dowel technique. At the same time, the wood has the normal score equation to bring waste materials for adding economic value together with an expression of environmental friendliness with non-chemical production. What is more, it is based on the local wisdom to join in the production of traditional Thai furniture that is considered a development with creating of sustainable development in the locality to be balanced as follows: 1) The Economy, 2) The Community, and 3) The Environment that develops in a positive direction from the application of the research results.

Keywords: *Geometric Shape Wood Joint Technique, Creation of Lanna Thai Teak Furniture, Teak Wood of Thailand.*

Introduction

Forests cover one-third of the world's land and are significant in the lives of humans and all kinds of

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animals based on nature. Human civilization has developed so rapidly that it has resulted in the massive destruction of forests worldwide, according to the results of the Global Forest Resources Assessment (FRA) 2015. Similarly, it was found that [1-2] the world's forest area is reduced by 3.3 million hectares every year, and deforestation, which has increased in the present, is considered a severe threat to the ecosystem. Additionally, the tropical agricultural area has approximately 11% of the total area with GHG emissions, consistently high levels since the first industrial revolution until now, affecting our human life in modern times. Similarly, in modern times, humans need to preserve nature and the environment to be along with our people's lifestyle sustainably, and humans must change the method of applying limited resources for maximum value and benefit. [3] The need to create sustainable development in the agricultural society of Thailand is based on the wisdom of the community to create the economy together with sustainability for the environment. Additionally, it also helps generate stable income for people in modern times appropriately, significantly to improve the lives of people with environmental friendliness. It can then apply the principles of the circular economy to participate in responses to create sustainable positive effects on the global environment. [4] In this case, it is essential to ensure stability in normal people and local people's lifestyles, especially for the existing local materials to be applied to create products to respond to the needs of community people. It can then promote the development of a green business model system with a more friendly environment by developing skills and craftsmanship in the community with good potential for local resources. In this case, it can appropriately show the uniqueness of the ancient intellect in Thailand by using the wisdom of ancient wooden pivots as a material development guideline for a friendly environment. This process has positive results: 1) Helping to create additional careers for farmers. 2) Making Strength for the community; 3) Creating friendly products for the environment; 4) Helping to create new furniture production techniques for entrepreneurs in the community; 5) Helping to develop teak furniture products based on local wisdom; 6) Developing furniture with market demand in the present era; and 7) Creating sustainable income for the local people [5–7]. Finally, all management is operated under environmental friendliness to ensure sustainable development.

The global furniture market is growing at over 41.8% or $226.6 billion in A.D. 2028, with a projected compound annual growth rate (CAGR) of 5.5% in A.D. 2021-2028. The growth of the world market is -10 percent, which is a positive demand shock phenomenon worldwide. Since the outbreak of Covid-19, there has been a need for consumers to pay attention to the furniture that is beautiful and functional. In addition, climb consumers have shown a demand for furniture that is thoughtful and meticulous in design, focuses on beautiful shapes, and uses environmentally friendly materials. Similarly, consumers also require furniture made from more sustainable materials, especially teak wood, to be considered a high-value material. In this case, consumers have shown the highest demand compared to other wood materials available in the market, [8] and it is the needs of consumers in the future with the demand for sustainable furniture that also has the most negligible impact on the environment. In this case, the furniture showing sustainability should have the following characteristics: 1) Using natural materials 2) Using materials without chemicals 3) Using local materials for production 4) Using materials with a long life 5) Materials representing sustainability [9–10] with others.

 Many communities in Thailand are developing their local raw material potential to create economic value and market opportunities for themselves [11]. In this case, communities in Thailand also develop strategies that demonstrate sustainability for the surrounding environment. Furthermore, some principles need to be considered with environmental, economic, social, and business aspects, as well as the use of sustainable materials. [12–14]. Then, Teak is the material that communities in Thailand have chosen to use, [13,11,12] which is an abundant resource in Thailand with its beauty and durability for gaining a lower carbon footprint than other building materials [15,16].

Moreover, the Thai government has encouraged farmers to cultivate large amounts of Teak in northern

Thailand for plant replacement in abandoned areas or degraded forests. Subsequently, the government provided seedlings to the Forest Industry Organization by supporting the budget for planting in community areas. Thus, when the Teak is 7-12 years old, [17] it will grow leaves with wide roots. After that, the grasping of food and air decreased teak growth. [15] Therefore, it uses the cutting technique to extend the length of the teak tree, and the purpose of pruning and expanding is to manage the density of teak trees by cutting off some parts of the trunk to obtain the grower remaining wood. According to the method of cutting and expanding the rows of teak plants, farmers prefer to use easy mechanical or geometric thinning methods; however, they do not require cutting and expanding the distance. Similarly, the cut Teak can be selected by considering the spacing between the teak trees to prevent stem bending and stunting due to teak diseases. [18–20] Many teak trees have been cut and spread out of plantations, and farmers often burn these young teak trees to make firewood [21] or as a household fuel. In this case, it can be used as burning to affect the environment adversely and is considered a waste of valuable natural resources without proper value. As a result, it also greatly impacts the environment and is another reason for the greenhouse effect.

Leftover timber can be incorporated into furniture design using the geometric dowel method to advance the concept of maximizing the use of teak from the trees. The geometric dowel method has been considered a way to use the leftover teak scraps from cutting and relies on local ancient wooden dowel wisdom to help produce in this modern age. In addition, this research aims to study the results from applying two techniques: 1) Wood Drying, 2) Wood Soaked in Water and Sun-Dried.

This research will test the obtained teak wood for shear strength to ascertain the highest strength geometric dowel. After that, it will include teak into traditional Thai furniture design based on the cross-impact matrix assessment results. The results can be used to develop, take apart and reassemble traditional-style Thai furniture to encourage the community to use the teak that has been considered tree-cutting waste developing furniture. It can be appropriately marketed and help create sustainable development for the community that grows sustainable teak wooded area and generate an income for the community.

This research aims to utilize teak leftovers from cutting and expanding the planting rows to produce traditional Thai furniture, which can be disassembled using geometric doweling techniques. Also, study the efficiency of two types of spikes. The research will rely on indigenous wisdom to detail the doweling method and create a balance between wisdom and the community environment. The result intends to promote sustainability for the community and the environment simultaneously.

Research Objectives

To apply geometric-shaped wood joints from thinning teak to expand the planting line for the production of more sustainable traditional Thai furniture production by using the disassembly technique of the economic teak plantation community in Thailand.

Literature Review

Geometric Concepts and Design

According to the geometric concept of [22] Kendall, D.G. (1984), the properties and structure of geometric shape is appropriate for creating products by placement and shape creation from the physical characteristics of geometry. In this case, it reflects shapes that can be applied geometrically in the product design to create expanding, shrinking, and rotating shapes.

The shape design process is expressed in 2D, while the appearance is expressed in 3D. Therefore, it is considered to combine both 2D and 3D features with geometric shapes to create a relationship that represents the association between a point and a line, where the points and lines are the starting points of shapes found within nature. Then, when it is fused, it will result in a polygon (polygon), such as a triangle, cube shapes, cone shapes, spherical shapes, and others. Thus, these shapes are the natural shapes that designers often apply to create product designs from the ancient Greek era until the civilization of Mesopotamia. Geometry has always played a role in creating a prosperous civilization and appears to be used throughout the history of mankind. [23–35]

In this research, the shapes in the geometric group are called geometric shapes, such as square, triangle, circle, rectangle, oval, and diamond. They are combined in the creation of furniture dowels and furniture shapes with structural design and structural organization. [34,35].

This research developed wood jointing from the application of five geometric shapes, as shown in Table 1.

Table 1: Showing of the Geometric Definition and Design Implications.

Shape	Design Definition	shapes that appear in nature
Rectangular and Square Shapes [23,34–36]	Shapes representing stability and confidence by creating strength to workpieces with square shapes	
Triangular Shape [23,34–36]	A shape showing tension and conflicts, which are often strong and stable with equal balance to be found as symbols of equality or stability	
Sphere [23,34–36]	A shape expressing positive emotions and representing unity and harmony	
Hexagon [23,34–37]	A shape representing strength and sophisication with showing of the future world that appears novelty	

Currently, research has developed wooden joints with geometric shapes in furniture design, and all research results indicate that the strength of the wooden joint depends on the shape of the wooden joint that is used in the manufacture of furniture [38-41]. However, this does not depend on the strength of the parts.

Shear Strength Test

Based on research by Anand Nandanwar. et al. [42], it was found that it can test for the strength of the wooden joint. Then, it should have three types of strength assessments:1) shear 2) bending and 3) tensile strength and others, which the evaluation will use a stress testing machine joint. Finally, these data can be shown in terms of the efficiency of the joint in each geometry.

Cross-Impact Matrix Analysis

Theodore Gordon and Olaf Helmer developed a cross impact-matrix analysis method, and it is a methodology to analyze interactions between events. It is a method for estimating the likelihood of an event that may occur by analyzing the effects that occur horizontally and vertically. Thus, the likelihood of a likely event and its marks in the matrix can be considered;

1.   If the trend is most likely Put a sign (+ +)
2.   If there is a tendency to occur Put a sign (+)
3.   If there is a slight tendency Put a sign (-)
4.   If there is a tendency to rarely occur Put a sign (--)
5.   If there is a tendency to not occur or unknown   put a mark (0)

This characteristic analysis matrix clearly shows the direction of events with the relationship between events. Moreover, a limitation of this method is related to determining the direction of the matrix relationship, which is an individual process. Therefore, accurate determination requires an experienced informant who is clearly and highly experienced in the subject matter to be able to receive complete research details [43–45].

In this part of choosing the style for wooden joints in the production of Thai Lanna furniture from the extended range of carded teak, it shows that the researcher has studied to assist in selecting geometric shapes by creating the characteristics of the wooden joint, as shown in Table 2.

Table 2: Selection of Wood Joint Patterns in the Production of Thai Lanna Furniture from Extended-Length Carding Teak

Factor	Description	Reference
Ease of Production [11,46–49]	1. The production process is convenient. 2. It can reduce for production costs 3. It has less waste from production process 4. It is environmentally friendly. 5. It is able to produce a variety of furniture.	
Uniqueness [15,47,50,51]	1. It is a local identity 2. It is a modern and novel shape. 3. The product is beautiful.	
3. Suitability for Medium and Small Industries [7,46,47,52–54]	1. The production process demonstrates environmental sustainability. 2. It is convenient to transport. 3. It can reduce for production costs.	

Methodology

The Scope of Research on the Use of Splitting Teak to Test Joints and Joints in Geometric Shapes

a) The test can be classified into several patterns:1) Six patterns of geometric shapes for joints to be inserted by experimenting with two types of teak: 1) kiln-dried wood and 2) wood soaked in water and dried in the sun, based on the expert selection of the cut teak joint pattern. Experts had more than 15 years of experience in furniture production, totaling 20 people.

1. Oven-baked wood with testing can be classified into six types of the test by using the wooden joints) Form A with three pieces of size 20 × 20 mm; 2) Pattern B with three pieces of size 20 × 20 mm; 3) Format C with three pieces of size 20 × 20 mm; 4) Pattern D with three pieces of size 20 × 20 mm; 5) Pattern E with three pieces of size 20 × 20 mm; 6) Pattern F with three pieces of size 20 × 20 mm, a total of six patterns with 18 pieces by testing three times to determine the variance of wood joint joints.
2. Wood soaked in water and dried in the sun can classify into six patterns in the wood joint: 1) Pattern A with three pieces the size 20 x 20 mm 2) pattern B with three pieces the size 20 x 20 mm 3) Format C with three pieces as the size 20 x 20 mm.
3. Pattern D with three pieces as the size 20 x 20 mm 5) pattern E with three pieces as the size 20 x 20 mm 6) format F with three pieces as the size 20 x 20 mm, a total of six patterns with eighteen pieces to be performed with three times for knowing the variance of wood joint joints

b) The test method and leadwood jointing can be classified into the following patterns. 1) Wood Drying 2) Wood soaked in water and dried in the sun with three pieces per style to be tested for labor cost by shearing the seam and bringing the results to the experts for selecting the pattern of the wooden joint, amounting to 20 people.

c) Research Equipment - mechanical properties according to Standard Test Methods for Small Clear Specimens of Timber D 143–94 Reapproved 2000 and cross-impact matrix method selection of the joint pattern.

d) Data analysis - called mechanical properties according to Standard Test Methods for Small Clear Specimens of Timber D 143–94 Reapproved 2000 with shear type and data analysis to join in the joints using the Cross-impact matrix method.

### Scope of Research in Satisfaction Rating

1. The population group is the furniture and wood product trade association of Phrae Province and Consumers of teak wood products attending Phrae Craft 2022 at the Forest Development Institute (Old Forest School) in Phrae Province with 254 people
2. The sample group consisted of 254 people:1) trade associations of entrepreneurs' furniture and wood products in Phrae Province with 53 people, 2) teak consumer groups participating in the Phrae Craft 2022 event at the Forest Development Institute (Old Forest School) in Phrae Province with the fifth time for 201 people using simple random sampling according to the data import criteria at the 90% confidence level of Taro Yamane [55].
3. The research tool is a structured questionnaire on the feelings toward traditional Thai wooden furniture styles from splitting teak, and the questions were set in observable variables and were measured on the Rating Scale at five levels of liquors; all 12 items were found to be confident by Cronbach's alpha coefficient = .942, which is considered to be at an outstanding level. The questionnaire was reliable and could be used to collect data from the sample group.
4. Data Analysis Using Multiple Regression Analysis (MRA).

Strength Test of Geometric Wooden Joints Made from Sheared Teak with Shear Force

In this case, a 12-year-old cut-down teak was tested by baking and soaking. After that, it was dried in the sun according to the folk wisdom of northern Thailand before being put into the testing process. The characteristics of 12 the year extension of carding teak wood include the process of preparing the teak material before testing:
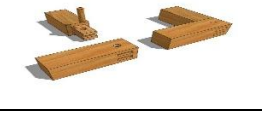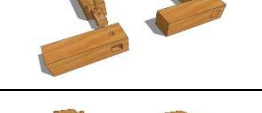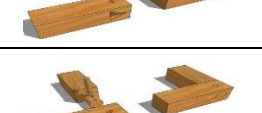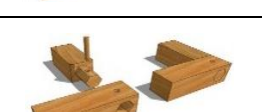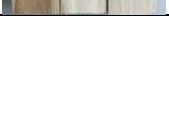
1. Dry wood at a temperature of 50 °C until the 7th day of baking. The temperature was then increased to 80 °C and baked at this temperature for another 20 days, with a total baking time of 27 days.
2. Wood was soaked in water and dried in the sun by first soaking in water for four days. It is then exposed to the sun at normal temperature for 27 days for 31 days, and the total average climate temperature is 31.1 Celsius per day.

Picture 1: Air temperature from 15/09/2022 until 12/10/2022
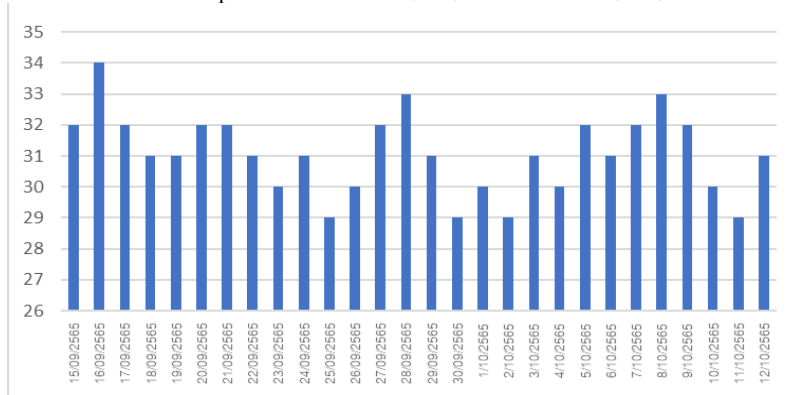
Characteristics of Splitting Teak Extended the Distance in the Shear Joint Test

Table 3: Patterns of the Expansion of the Teak Joint

Code	Wooden Joint Pattern	Wooden Joint Pattern	Description
A			jointing in wooden planks are not fully connected or not close together with slots for inserting joint pins.
B			Rectangular wooden joints look like they are stacked together with hole for inserting the joint pin
C			Square wooden joints are with equal shape dimensions on all six sides with anchor bolt slots
D			The triangular wooden joint is with the base of the triangle to support the pressure with a slot by inserting in the joint fixing bolt
E			A circular, cylindrical wooden joint is with a hole for the joint
F			A hexagonal joint inserts with joint pin slots

Then, it should take twelve forms of wooden joints by testing with a mechanical properties tester and analyzing the data according to Standard Test Methods for Small Clear Specimens of Timber D 143–94 Reapproved 2000 [56]. Moreover, it is a force applied to geometric joints from the Department of Civil Engineering at the Faculty of Engineering, Chiang Mai University, Thailand. Then, the top three most vital wooden joint patterns were selected by a group of experts and used to develop traditional Thai furniture as the next step.

Selection of the Jointing Pattern by Using the Method of Cross-Impact Matrix

Twenty experts with furniture production knowledge and over fifteen years of experience were requested to complete a questionnaire on the dowel suitability selection for application in the wood joint method. In this case, the expert group was selected by applying Macmillan [57]; the number of experts required was within the range of 17–21 with a 0.5 margin of error, as shown in Table 4.

Table 4: Experts in the Selection of Wooden Joint Patterns from Short-Cut Teak

Expert Group	Quantity
Engineer : Engineering teacher in Thailand	5 people
Product Designer : A design practitioner in Thailand.	5 people
Local artisans in furniture production : furniture entrepreneurs in northern Thailand	5 people
Medium and large manufacturers in the northern region of Thailand	5 people
Totals	20 people

This research was accredited according to the ethical standards of the Institutional Review Board (IRB) of King Mongkut's Institute of Technology Ladkrabang.

Satisfaction Assessment to Select the Appropriate Model

1) Product design process: The results obtained from testing the strength of the wooden joints were applied to the design of Thai Lanna furniture. Subsequently, consumer satisfaction was assessed by the Trade Association of Wood Product Entrepreneurs in Phrae Province. 2) Consumers of teak wood products should participate in the Phrae Craft 2022 at the Forest Development Institute (Old Forest School) in Phrae Province for the fifth time.

Picture 2: Results in Creating Thai Lanna Furniture Products from Cut Teak Wood

(Design Concept)   (Brainstorming for Creativity)

Picture 3: Prototype of Thai Lanna Furniture Products from thinned teak

According to the furniture design concept, creativity brings knowledge of the properties of teak spurs to be applied to the design of traditional Thai furniture products. Moreover, it focuses on creating novelty in materials and production, including sustainability, showing environmental friendliness, and creating economic value and sustainable ways of life for teak farmers and furniture makers. Thus, it can increase the economic value of manufacturers [58]. Similarly, furniture using the jointing technique is based on an extension of ancient Thai wisdom that considers a combination of cultural costs inherited from the past of skilled craftsmen in Thailand. Thus, it can respond to consumers and help reduce the loss of teak wood materials left over from thinned teak by bringing this worthless teak wood back to use in production and reducing the environmental impact. Finally, this is an expression of the community's environmental responsibility for the teak plantations.

Results

Test Results of Strength Test for Geometric Wooden Joints by Shearing Teak

The shear test with mechanical properties testing and analyzing data is the Standard Test Method for Small Clear Specimens of Timber D 143–94, Reapproved in 2000 for testing results with a shear strength of wooden joint joints. Moreover, it uses the treatment method of joining a wooden joint with three sets of each type to be tested, as listed in Table 5.

Table 5: Joint Strength Results

Baking Wood							
Types of Joining Joints	A	B	C	D	E	F	Mean Value of Type for Joining Joints of Kiln-Dried Timber
Mean Blaster Shear (kg)	1,931	1,968	2,166	1,744	2,356	2,223	2,064.67
Soaked and Sun-Dried Wood							
Types of Joining Joints	A	B	C	D	E	F	Mean Values of Type for Joint Joints with Soaked and Sun-Dried Wood
Mean Blaster Shear (kg)	1,686	2,121	2,162	1,724	1,914	2,227	1,972.33
Average Value by Type of Joint Joint	1,808.5	2,044.5	2,164	1,734	2,135	2,225	

According to the shear strength test results for wood joint inserts, the shear strength should be considered. Moreover, it was found that kiln-dried wood had an average shear strength of 2,064.67 kg, which is higher than wood soaked in water and sun-dried with an average shear strength of 1,972.33 kg. for wood drying and soaking, respectively. Moreover, drying in the sun had similar averages with the strength according to the type of geometric joint, and it was found that the type of joint showed the highest and lowest shear strengths as follows:1) The circular joint had the ultimate shear strength at a level of 2,356 kg. 2) The hexagonal joint had an average shear strength of 223 kg at level 2. 3) The square joint had an average shear strength of 166 kg at level 2. 4) The square joint had a mean shear strength of 968 kg at Level 1. 5) The unfinished joint had a mean shear strength of 931 kg at Level 1. 6) The triangular joint had a shear strength of 744 kg for the Class 1 average blaster.

For the part of the wood soaked in water and dried in the sun, it was found that the wooden joint with the highest to the lowest shear strength test showed the following details:1) the hexagonal joint had an average shear strength of 227 kg at level 2, and 2) the square joint had an average shear strength of 162 kg at level 2. 3) The rectangular joint had an average shear strength of 121 kg at Level 2. 4) The circular joint had an average shear strength of 121 kg at Level 2. The average deadly shear strength at level 1 was 914 kg. 5) The triangular joint had an average deadly shear strength of 724 kg at level 1. 1 and 686 kg, respectively. In conclusion, according to the shear strength test of the joint type, the hexagonal joint had the highest shear strength, and the triangular joint had the highest shear strength with a minimal shear correlation curve.

Fig. 4: Correlation Graph of Shear Stress from the Joint Type of Joint Insertion
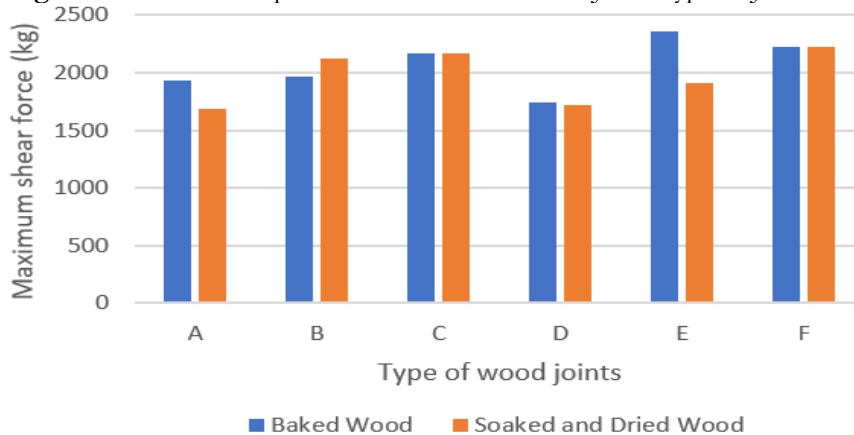
According to the shear test results from the blaster of the six types of joints, the researchers selected the first three shearing joints:1) square joint, 2) circular joint, and 3) hexagonal joint. The researcher then brought three sets of prototypes from the wooden joints to test the settlement distance caused by the shear stress at different levels. In addition, according to the mechanical properties testing machine and analyzing data with the Standard Test Methods for Small Clear Specimens of Timber D 143–94 Reapproved 2000, it was found that the type of veneer settling distance at 500 kg had the shear force as these details: 1) The Hexagon Joint Pattern of subsidence with 1.32 mm. 2) A circular joint pattern with subsidence of 1.22 mm. 3) Square Joint Pattern of subsidence with 1.54 mm.

There are many types of wood joints with the best shear recession distance:1) square joints, 2) circular joints, and 3) hexagonal joints, as shown in Table 6.

Table 6: The Results of the Settling Distance at the Shear Strength of 500 kg and 1,000 kg for All Three Types of Veneer Type

Joint Type	C	E	F
Settlement Distance at 0 kg shear (mm)	0	0	0
Settlement Distance at 500 kg shear (mm)	0.77	1.22	1.32
Settlement Distance at 1000 kg shear (mm)	1.54	2.88	3.62

According to the type of wood soaked in water and dried in the sun, it showed the settlement distance at a shear stress of 500 kg with the highest value:1) a hexagonal joint pattern with subsidence of 1.33 mm 2) a circular joint pattern with subsidence of 1 mm. 3) A square joint pattern with subsidence of 0.94 mm. In addition, it showed the settlement distance at a shear force of 1000 kg as follows:1) hexigon joint with a subsidence of 3.65 mm. 2) Circular joint pattern with a subsidence of 2.83 mm. 3) A square joint pattern with a subsidence of 1.85 mm. In this case, the joints with the slightest setback and shear strength guarantee were as follows:1) square joints, 2) circular joints, and 3) hexagonal joints, as shown in Table 7.

Table 7: Settlement Distance Results at 500 kg. and 1,000 kg with Shear Strength for All Three Models Types of Wood Soaked in Water and Dried in the Sun

Joint Type	C	E	F
Subsidence Distance at 0 kg Shear Force (mm)	0	0	0
Settlement Distance at 500 kg Shear Force (mm)	0.94	1	1.33
Settlement Distance at 1000 kg Shear Force (mm)	1.85	2.83	3.65

From the shear strength test results of all six types of dowel joints, the researcher selected the top three: 1) square dowel, 2) circle dowel, and 3) hexagonal dowel.

Experts then evaluated the three types of dowels to select the most suitable dowel to produce traditional Thai furniture by analyzing the Cross-sectional impact matrix.

The Result of Selection of the Cross-Impact Matrix Method

According to the analysis results with the interaction table from the cross-impact matrix, the researcher defined the relationship between production characteristics and joint wood characteristics at three levels:1) very appropriate (+1), 2) less suitable for each other, and 3) not suitable for each other (0). Thus, the researcher will count only the +1 value to be used in the selection of production characteristics suitable for using the wood joint method with a value of 70 percent or more, as shown in Table 8.

Table 8: Opinion Values for the Evaluation of Suitable Wood Joint Inserts for the Development of Antique Thai Furniture Products

Thinned teak Characteristic Suitability Assessment List	Wood Soaked in Water and Sun Dried (Entering the Joint)			Baking Wood (Entering the Joint)		
	A	**B**	**C**	**A**	**B**	**C**
1. Convenience and speed of processing for the production process						
Easy to develop and produce furniture	18 (90%)	12 (60%)	15 (75%)	20 (100%)	12 (60%)	13 (65%)
Gaining strength with suitablility for product development	20 (100%)	14 (70%)	16 (80%)	18 (90%)	13 (65%)	16 (80%)

Being convenient to be processed into furniture products	18 (90%)	10 (50%)	14 (70%)	17 (85%)	10 (50%)	14 (70%)
Little loss of wood during processing	20 (100 %)	10 (50%)	13 (65%)	20 (100 %)	10 (50%)	13 (65%)
Being processed into Furniture for many forms	20 (100 %)	14 (70%)	16 (80%)	20 (100 %)	14 (70%)	16 (80%)
2. Beauty and Identity						
Gaining the identity of Thai Lanna furniture	18 (90%)	13 (65%)	19 (95%)	17 (85%)	14 (70%)	20 (100%)
Showing of the uniqueness of teak wood	16 (80%)	13 (65%)	18 (90%)	15 (75%)	14 (70%)	20 (100%)
Gaining for Novelty of Wooden Joints	18 (90%)	13 (65%)	19 (95%)	18 (90%)	15 (75%)	20 (100%)
The Wooden Spur Reflecting with the Uniqueness of the Wisdom for the Thai Lanna people	16 (80%)	16 (80%)	16 (80%)	16 (80%)	16 (80%)	16 (80%)
Wooden spurs creating sales Opportunities	18 (90%)	13 (65%)	19 (95%)	17 (85%)	14 (70%)	20 (100%)
3. Medium and Small Industrial Production						
Helping promote the development opportunities of the community's small and medium industries	17 (85%)	12 (60%)	15 (75%)	17 (85%)	14 (70%)	18 (90%)
Suitable wood joints for use in modular systems	20 (100%)	13 (65%)	15 (75%)	20 (100%)	14 (70%)	15 (75%)
Being convenient to transport and reduce transportation costs for operators	20 (100%)	15 (75%)	15 (75%)	20 (100%)	17 (85%)	15 (75%)
Consumer needs	16 (80%)	14 (70%)	15 (75%)	16 (80%)	16 (80%)	14 (70%)
Ease of disassembling	20 (100%)	14 (70%)	15 (75%)	20 (100%)	15 (75%)	14 (70%)
Average	91.67 %	65.33%	80%	90.33%	69.33%	81.33%

* A = Square joint, B = Round joint, C = Hexagon joint

The wooden joints that passed the criteria were square wooden joints of baked wood and wood soaked in water and sun-dried. Moreover, there were two evaluation means for wooden joints:1) the mean of the sun-dried wooden square joint was 91.67 percent, and the mean of the dry-soaked wooden joint square was 90.33 percent. The square-shaped timber of the cut teak was then extended to develop a prototype of Thai Lanna furniture that can be disassembled in the following research phase.

Satisfaction Evaluation Results on Furniture Styles Thai Lanna from Teak Wood by Cutting with the Thinned teak

Picture 5: Brainstorming Through the Process of Creating Thai Lanna Furniture from Sheared Teak to Create a Sustainable Community Economy

Table 9: Consumer Satisfaction Towards the Style of Antique Thai Furniture From Teak, Cut and Spread the Distance

Number	Satisfaction Assessment (n=254)	Mean	S. D.	level of satisfaction	Skewness Statistics	Std.Error	Kurtosis Statistics	Std.Error
1. Aesthetic								
1.1	Unique shapes that represent local cultural values	4.22	.670	High	-.290	.153	-.798	.304
1.2	Ancient Thai furniture.	4.33	.705	High	-.627	.153	-.523	.304
1.3	Outstanding shape of the furniture desired by consumers	4.14	.736	High	-.410	.153	-.484	.304
1.4	Furniture shape with the ancient Thai way of life	4.28	.720	High	-.667	.153	-.116	.304
	Totals	4.24	.600	High	-.423	.153	-.534	.304
2. Functional								
2.1	Convenient for the production of local craftsmen in small and medium communities	4.21	.684	High	-.448	.153	-.233	.304
2.2	Consumers can easily disassemble by themselves.	4.26	.776	High	-.633	.153	-.581	.304
2.3	Convenient transportation	4.28	.764	High	-.745	.153	-.209	.304
2.4	Passing the standard test TIS.	4.33	.700	High	-.620	.153	-.497	.304
	Totals	4.27	.630	High	-.573	.153	-.398	.304
3. Symbolic								
3.1	Encouraging the use of pruning lumber to create a community economy.	4.41	.664	High	-.767	.153	-.135	.304
3.2	Friendly environment production process	4.41	.704	High	-.758	.153	-.656	.304
3.3	Characteristics of patterns for teak wood, cut at intervals to be unique and suitable for production with Ancient Thai furniture of the community	4.35	.677	High	-.650	.153	-.337	.304
3.4	Appropriateness of using splitting teak to generate income in the community	4.35	.647	High	-.477	.153	-.685	.304
	Totals	4.38	.578	High	-.717	.153	-.242	.304

Two hundred and fifty-four **consumers** completed a questionnaire about the question, "What satisfies **consumers** with the traditional Thai furniture style from cut teak. The sequence showing the demand for traditional Thai furniture from cut teak has been extended as follows: 1) Symbolic Product **Satisfied** at a **high** level. (Mean =4.38 ; SD = 0.58) 2) Functional **satisfaction** at a **high** level. (Mean =4.27 ; SD = 0.63) and 3) Aesthetic **Satisfied** at a **high** level. (Mean = 4.24; SD = 0.60), and overall, consumers **were** satisfied with all three **factors** at a **high** level. (Mean =4.30 ; SD = 0.60).

According to the results of data distribution with Normality Testing, it was collected two hundred and fifty-four data from three aspects:1) Aesthetic 2,) Functional, and 3) Symbolic Thus, the skewness and Kurtosis values less than +/-1 were considered to be complete for parametric analysis and Hair et al., 2019 p.100 [59]. With this case, it is said that if n from 200 Normality [60]. Abs, Z Skewness < 3 and Z

Kurtosis < 10, assuming that the data is not skewed and too high to be accepted, and the analysis of research results is shown in Table 10.

Picture 6: Relationship between independent (X) and dependent (Y) variables
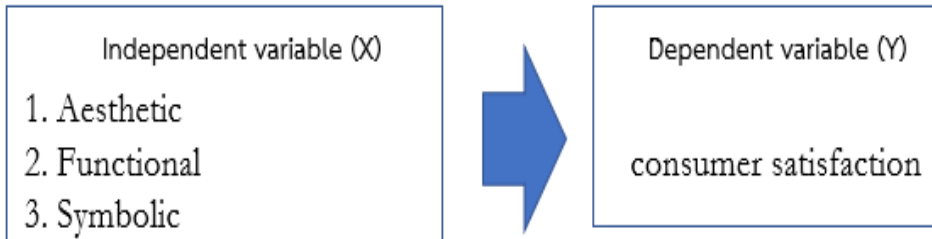
According to the analysis, it appears as follows:1) Residual Mean=0, 2) a standard distribution curve with the information below the normal distribution line and no out-of-bounds values shown in the analysis, 3) independent variables and dependent variables with a linear relationship, and 4) variables with equal variance assumed from using Scatterplot. In addition, the arrangement of the data from a band slope in the left corner to the right corner and data without clutter indicates that the analyzed data are suitable for fact-finding.

By defining three independent variables: 1) Aesthetic, 2) Functional, 3) Symbolic, and the dependent variable from the satisfaction of the consumers. In this case, according to the Model Summary Test, it was found that all three independent variables were able to predict the dependent variable 8 0. 5% (R Square =. 805; R =. 897; Adjusted R Square = .803), which meets the minimum criteria at level 20%.

Table 10: ANOVA

Model	Sum of Squares	df	Mean Square	F	P-value
1 Regression	58.928	3	19.643	345.090	.000
Residual	14.230	250	.057		
Total	73.159	253			

According to the analysis of the ANOVA table to be statistically significant, Sig. = .000; it involves a multiple regression equation with phenomenal from the requirement to study.

Table 11: Correlation Coefficients of Factors Affecting Consumer Satisfaction Toward Lanna Furniture from Split-Plank Teak

	Variable (Y)	Aesthetic	Functional	Symbolic
Variable (Y)	1.000	-	-	-
Aesthetic	.841 **	1.000	-	-
Functional	.786 **	.752**	1.000	-
Symbolic	.825 **	.760**	.744**	1.000

** $p < .01$

The factors affecting the satisfaction of the consumers with the antique Thai furniture from the split-cut teak showed the following details:1) aesthetic, 2) functional, and 3) Symbolic with the level 0.01 as a correlation coefficient of .744 - 841. In this case, the variable with the highest correlation coefficient was aesthetic, with a correlation coefficient of .841, ranked two Symbolic. has a correlation coefficient of .825, and the 3rd place functional has a correlation coefficient of .786.

Table 12: Results of Stepwise Multiple Regression Analysis

Model	Unstandardized Coefficients		Standardized Coefficients	t	P-value	Zero-order	Collinearity Statistics	
	B	Std. Error	Beta				Tolerance	VIF
1 (Constant)	.426	.119		3.567	.000			
AEST (X1)	.371	.043	.414	8.709	.000	.841	.345	2.901
FUNC (X2)	.181	.039	.212	4.597	.000	.786	.364	2.744
SYMB (X3)	.328	.044	.352	7.511	.000	.825	.354	2.828
R= 0. 897, R ^{2}=0.8 05, Adj R ^{2}=0. 803, SEE= 0. 23858, Durbin-Watson= 1. 842								

* p < .01

According to the results, it showed aesthetic (β =.371, t=3. 567, P-value=. 000), symbolic (β =.328, t=7. 511, P-value=. 000), and functional (β =. 1 81, t = 4. 587, P-value =.000). Then, all three factors significantly affect the satisfaction of consumers toward the traditional Thai furniture style from cut teak with extended length, and the statistical value of .01 is shown in Table 12.

- Regression equation in raw score form.

$$\hat{y} = .426 + .371(X_1) + .181(X_2) + .328(X_3)$$

- Regression equation in standard score form.

$$Z = .414(X_1) + .212(X_2) + .352(X_3)$$

Discussion

Strength test of geometric wooden joints with cut teak, extended 12 years by shear force.

According to the test of the strength of the geometric wooden joint with shear force, the thinned teak was spread with wood treated in two ways:1) kiln-dried wood and 2) wood soaked in water and dried in the sun. Moreover, the shear strengths of both types of wood are similar; the strength test results for the joints of all six geometric shapes with a triangular pattern have the lowest shear strength and hexagonal joints. In addition, it has the highest shear strength, which is similar in value to a square joint of the three types. Subsequently, the teak joints with the highest strength were selected by averaging the two types of splitting teaks in three ranks:1) a hexagonal wooden spur pattern with an average shear strength of 2,135 kg. 2) Square joint pattern with an average shear strength of 2,164 kg and 3) circular wood pattern with an average shear strength of 2,135 kg, according to Ali Kasal. et al. (2013) [61]. Moreover, according to the study, it was found that the creation of a wooden joint can withstand a shear force of at least 2,064 Newtons, which is considered a property of wooden joints that is strong enough to be used to produce furniture for this use. As a result, this value can be used as a standard value to check the shear strength of joints or joints.

Choosing a Cross-Impact Matrix Method

The cross-impact matrix method was used to select wooden joints. Moreover, it was found that hexagonal joints were suitable for furniture production, showing suitability for the beauty and identity factors. Thus, the feature of the hexagonal joints is to highlight memorable details by characterizing the meticulous craftsmanship of the furniture maker. Similarly, it can also represent the novelty of new wooden joints by helping to create an identity of ancient Thai furniture that can be disassembled. This follows the hexagonal shape, which represents strength and is unique; the hexagonal wooden joint is considered an interesting joint pattern. As a result, it shows the appearance of beauty and identity that are highly unique, and it can withstand high shear forces compared to all six types of joints.

In this case, square wooden joints are convenient and quick to manufacture, and a small amount of

wood is lost in the process. It can then produce furniture in medium and small industries managed by the community. In this case, in the northern part of Thailand, local technicians are proficient in the production of joints, and they local technicians will have expertise suited to the nature of the tools that the technicians in the community have.

According to the choice of paying attention to the square spur in a wooden square is soaked in water and the sun because the characteristics of this type of spur will help show high environmental friendliness. Moreover, it is also involved in the strength of the teak spur, which is high and stable compared with wood drying. Similarly, it also helps save production costs more than wood drying techniques [13,62,63]. In this case, these techniques focus on minimizing energy consumption in production applications. Therefore, a model that represents the highest environmental sustainability was considered.

Satisfaction Evaluation Results of Traditional Thai Furniture Styles from Thinned Teak Wood

As a result, according to the satisfaction assessment and antique Thai furniture from thinned teak, this is consistent with the potential of the community and the environment. Moreover, it considers the connection between aesthetic, functional, symbolic, and other factors. Thus, it can order the importance of factors from high to low as follows:1) Symbolism: encouraging the use of teak wood, thinned teak to have a unique wood pattern, and helping create a distinctive identity and ancient Thai furniture with economic value for the community by relying on environmentally friendly production processes. Therefore, the characteristics of teak joints were chosen to create convenience for the production process of local technicians in the community, an establishment with small and medium sizes, and it produced a joint of teak wood. Therefore, consumers can easily disassemble and assemble themselves, resulting in cost savings for transporting goods for sale. 3) Beauty: Furniture shapes to be applied with a new jointing technique of a unique identity to show the local cultural value by reflecting ancient Thai furniture. In this case, it is based on the lifestyle of consumers, according to the consumer satisfaction questionnaire. Moreover, the three independent variables explain consumer satisfaction by 80 percent. Thus, the assessment was at a high level, and all three factors can be applied to forecast demand and consumer behavior, influencing traditional Thai furniture. Therefore, it was produced by the teak insert technique to be extended and able to support the community in generating income continuously from their local wisdom to inherit Thai culture from the past. In addition, consumers pay attention to the characteristics of environmentally friendly materials that have been designed using a combination of methods. Thus, the community's life in the past will result in a higher interest of consumers, which is the demand for antique Thai furniture produced from cut teak with the concept of creating environmentally friendly products. As a result, it will help create market opportunities to be more productive than competitive products [2,64,65].

It can apply young teak spurs arising from the cutting and row expansion to create furniture that focuses on creating sustainability for communities and consumers regarding the economy and environmental responsibility. Moreover, it is a highlight that helps stimulate consumer demand for "Sustainable furniture"[13,14,47,66,67] by focusing on bringing back waste materials. In this case, it uses the technique of joining geometric shapes by relying on a production process that is not complicated and does not use chemicals in the production process. Thus, it is significant in preserving the environment and can help generate a sustainable community income.

In this instance, it shows that the creation of sustainability for the economic tattoo planting group is necessary to promote the production process development to be sustainable by using teak, and it can gain economic value for the community that cultivates in response to consumer preference. Similarly,

it also helps reduce teak burning as a community household fuel, which is considered one way to help reduce the environmental impact. Therefore, future research results may help create three areas of sustainability: 1. Economic sustainability, 2. Sustainability of People's Lifestyle in the Community, and 3. Environmental Sustainability

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