



第4回  
アジア未来会議  
優秀論文集  
Best Papers of the 4th  
Asia Future Conference

# TOWARD THE FUTURE OF ASIA: MY PROPOSAL

アジアの未来へ  
—私の提案— Vol.4



今西 淳子【編】

Edited by Junko Imanishi

公益財団法人  
渥美国際交流財団  
関口グローバル研究会

Sekiguchi Global Research Association  
Atsumi International Foundation

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第4回アジア未来会議優秀論文集





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# Toward the Future of Asia: My Proposal

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# Toward the Future of Asia

Significance of our Conference and this Book

## Junko Imanishi

Representative, Sekiguchi Global Research Association, Atsumi International Foundation

The twenty-first century has seen the world thrust into a maelstrom of change and unpredictability. We remain hopeful in the face of rapid technological advancements, but many of us struggle to regain our bearings as longstanding social structures become upended. Internationalization and globalization have long been heralded as the keys for the future, yet a truly global path forward remains elusive, serving only to heighten the sense of uncertainty. As global citizens in this era of change, we are called anew to reexamine our world and our collective future and to seek new multidimensional and inclusive perspectives on myriad global issues.

The achievement of rapid economic development has also led to dramatic changes in Asia. At the same time, a complex set of transnational problems have been brought about by global environmental issues and increased socioeconomic globalization. In the midst of an ever-expanding understanding of “society,” the global citizenry—individuals, governments, and the business community—must adopt policies that not only allow for the pursuit of individual interests but also respond to concerns for the peace and happiness of society as a whole. Solving these problems requires the development of multifaceted evaluative and analytical strategies with cooperation across national and disciplinary borders.

The Asia Future Conference is interdisciplinary at its core and encourages diverse approaches to global issues that are mindful of the advancement of science, technology, and business and also take into consideration issues of the environment, politics, education, the arts, and culture. The Asia Future Conference is organized by the

Sekiguchi Global Research Association (SGRA) in partnership with like-minded institutions, in order to provide a venue for the exchange of knowledge, information, ideas, and culture, not only by SGRA members, but also by former foreign students of Japan from various educational institutions throughout the world, their own students and collaborators, and anyone interested in Japan.

SGRA began operating in Tokyo in July 2000 as a division of the Atsumi International Foundation, a charitable organization. At its core is a community of non-Japanese researchers who come from all over the world to conduct advanced studies in Japan and obtain doctoral degrees from Japanese graduate institutions. SGRA identifies issues related to globalization and seeks to disseminate research results to a wide audience through forums, reports, and the internet. SGRA’s aim is to reach society at large rather than a specific group of specialists through wide-ranging research activities that are inherently interdisciplinary and international. The essential objective of SGRA is to contribute to the realization of responsible global citizens. We look forward to welcoming a diverse and active group of conference participants.

Following the first conference (March 2013 in Bangkok), the second (August 2014 in Bali) and the third (September 2016 in Kitakyushu), Asia Future Conference was held in August 2018 in Seoul, Korea. There were nearly 400 full papers submitted to the conference. Of them, we here present the 19 best papers selected by an academic panel. We hope their suggestions will give hints to search for the new direction for the future of Asia.

# アジアの未来へ

アジア未来会議の趣旨とこの『論文集』について

今西淳子

渥美国際交流財団関口グローバル研究会代表

21 世紀にはいって世界全体に変革の嵐が渦巻き、人々は新しい技術に大きな期待を抱く一方、社会構造の激しい変化にとまどっています。国際化・グローバル化が唱えられて久しいのに、世界中で共有できる新しい方向性を見出すことができず、混乱は増すばかりです。このような時代においては、物事を新しい視点から複合的に分析し判断していくことが必要なのではないのでしょうか。しっかりした理念を持ち、それを如何に実践していくか、一人一人の意識の改革と行動が問われているのではないのでしょうか。

近年、アジアの各国は急激な経済発展を遂げていますが、地球環境問題の発生や社会経済のグローバル化の進展とともに、国境という枠組みを越えた問題が生じています。さらには、急激なグローバル化と同時に進むローカリゼーション、あるいはナショナリズムなど様々な問題が発生し、新しい課題となっています。社会の構成員である企業や市民は、個々の利益の追求と同時に、周辺社会の利益も検討しなければなりません。グローバル化が進む現代においては、従来の社会の範囲をさらに広げ、地球全体の平和と人類全体の幸福を目指すことが求められているのです。そして、様々な問題を解決する時、あるいは方針や戦略を立てる時、科学技術の開発や経営分析だけでなく、環境、政治、教育、芸術、文化など、社会のあらゆる次元において多面的に検討することが必要となっています。

アジア未来会議は、学際性を核とし、科学技術やビジネスの発展だけでなく、環境、政治、教育、文化芸術などからの多様なアプローチによってグローバルな諸問題に取り

組むことを狙いとしています。

アジア未来会議は関口グローバル研究会 (Sekiguchi Global Research Association: SGRA) が、同じ目的をもつ非営利のパートナー機関と共同で開催しています。SGRA 会員だけでなく、世界中の大学や研究機関に所属する日本留学経験者や、日本に関心のある人々が一堂に集い、知識、情報、アイディア、文化の交流を図りながらアジアの未来について語り合う〈場〉の提供を目的としています。

2000年7月から東京を起点として活動する公益財団法人渥美国際交流財団の一部署である関口グローバル研究会は、世界各国から渡日し長い留学生生活を経て日本の大学院から博士号を取得した知日派外国人研究者が中心となって活動し、グローバル化に関わる問題提起を行い、その成果をフォーラム、レポート、ホームページ等の方法で、広く社会に発信しています。ある一定の専門家ではなく、広く社会全般を対象に、幅広い研究領域を包括した国際的かつ学際的な活動を狙いとしています。良き地球市民の実現に貢献することがSGRAの基本的な目標です。

アジア未来会議は第1回(2013年3月、バンコク)、第2回(2014年8月、バリ島)、第3回(2016年9月、北九州市)に続いて2018年8月、韓国ソウルで第4回を開催しました。今回は400本近い論文が投稿されましたが、その中から厳正な審査により19本の優秀論文を選び、本書に収録しました。こうした若い研究者たちの提案が、アジアの未来への新しい方向性を探るヒントになることを願っております。



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# An Investigation on Coconut-timber Waste as Construction Material for Earthquake Resistant Wooden House in North Sulawesi, Indonesia



Rilya Rumbayan<sup>1</sup>, Donny Taju<sup>2</sup>, Rudolf Mait<sup>3</sup>

1, 2, 3 Senior Lecturer, Department of Civil Engineering, Manado State Polytechnic, Indonesia

インドネシアで大量に栽培されているココヤシ。生産力を維持するため、その木は定期的に植え替えられる。伐採された木は、そのままなら大量の廃棄物となるが、建材として利用すれば地震に強い木造住宅の普及につなげることができる。

## Abstract

This paper presents a current study into the use of coconut-timber waste as an alternative construction material to build earthquake-resistant timber house in North Sulawesi, Indonesia. The objectives of this research are: to obtain the physical and mechanical properties of coconut-timber, to identify the strength classification of coconut-timber, to design a model of earthquake-resistant house made of coconut-timber, and to perform structural analysis of the house under earthquake load. Research methods include: (1) Laboratory testing of the physical and mechanical properties comprising of moisture content test, density test, tensile test parallel to grain, compression test parallel to grain, compression test perpendicular to grain, shear strength parallel to grain, flexural test, and toughness. All tests were performed according to the American Standard Testing Material (ASTM) D143-09; (2) Identification of strength classification of coconut-timber based on the Indonesian Standard (SNI) 03-3527-1994; (3) Design of an earthquake-resistant coconut-timber house; (4) Calculation of the dimensions of structural elements of earthquake-resistant coconut-timber house; and (5) Testing of the performance of the coconut-timber house under earthquake load with ETABS software. Results from this research are expected to support the beneficial usage of local coconut-timber waste as construction material for timber house in an effort to mitigate the risk of earthquake hazard in North Sulawesi.

## Keywords

Coconut-timber; timber strength class; physical properties; mechanical properties; earthquake-resistant

## Introduction

North Sulawesi Province is one of the regions in Indonesia that has a high risk of earthquake because it is geologically located in one of the path of the Pacific Rim. Based on the map of earthquake regions used as a reference for structural building design, the province of North Sulawesi in Indonesia is located in Earthquake Region 5 which is categorized as a high-risk zone with earthquake scale between 5-7 Richter.

Building construction made of timber offers many benefits such as relatively higher structural stability and integration. This is due to the fact that timber has higher strength-to-weight

ratio compared to steel and concrete. This weight or mass of construction has a linear correlation to the lateral force (inertia) sustained by the construction. These properties have caused timber to become an alternative building material for earthquake prone areas such as North Sulawesi.

Coconut (*Cocos nucifera* Linn) is one of the many potential plantation crops commodity grown in North Sulawesi with a total area of 277.649 Ha in 2015, covering 15 districts. The total area is comprised of 37.675 Ha of coconut tree plantation that are not yet productive, 225.003 Ha of coconut tree plantation that are productive and 17.259 Ha of coconut tree plantation with

coconut trees aged over 50 years and needed rejuvenation because of their declining fruit productivity (Data from Dinas Perkebunan Prov. Sulut, 2015). This rejuvenation is needed to allow more space for new coconut plantation. The largest waste from the rejuvenation of coconut trees are the trunks from old coconut trees. If the trunks are left unprocessed, they can become breeding places for diseases that could strike coconut seedlings, which in turn will bring disadvantages to the local farming communities. Processing and utilization of the unproductive coconut trees as a construction material for timber house can be an alternative solution to the handling of coconut tree trunks after the rejuvenation, which will be beneficial to the local communities.

In general, the anatomical structure of a coconut tree consists of vascular bundle and ground tissue in the form of parenchyma. Macroscopically, there are differences in the density (distribution) of vascular bundle based on its location (height and depth) in the coconut tree trunk. More toward the center, the density of vascular bundle decreases, while toward the vertical the density of vascular bundle increases (Sudarna, 1990). The ability of vascular bundle as a support for timber strength is closely related to the thickness of fibre cell wall and silica content in the cell (Rahayu, 2001).

Density of coconut-timber varies depending on depth and height of the trunk. The density decreases with increasing trunk height and increases from the central part to the edge of the trunk. More toward the center of the trunk, coconut-timber is softer. Moreover, the density of coconut-timber also varies according to variety, location and age of the coconut tree (Polomar, 1990). Density of coconut-timber can be categorized into three based on the thickness of timber starting from the part closest to the bark. High density wood ( $\geq 0.6 \text{ g/cm}^3$ ) covers 53% of the trunk, generally located closest to the bark with thickness from 7.5 cm to 12.5 cm, having characteristic of very resistant to scratches; medium density wood ( $0.4\text{-}0.6 \text{ g/cm}^3$ ) covers 25% of the trunk, is in the thickness from 5 cm to 10 cm after the high-density-wood part, having characteristics of slightly resistant to scratches and cannot withstand humid weather; and low density wood ( $< 0.4 \text{ g/cm}^3$ ) covers 22% of the trunk, located in the center, quite soft, quickly weathered, cannot withstand scratches and humid weather.

The Indonesian standard about the quality and dimensions of construction timber, SNI 03-3527-1994, uses the physical properties (Air-dry Density) to classify timber into 5 strength classes (**Table 1**).

Table 1. Mechanical properties of timber

Strength Class	Air-dry Density	Absolute Flexural Strength (Kg/cm <sup>2</sup> )	Absolute Compressive Strength (Kg/cm <sup>2</sup> )
I	$\geq 0.90$	$\geq 1100$	$\geq 650$
II	$0.90 - 0.60$	$1100 - 725$	$650 - 425$
III	$0.60 - 0.40$	$725 - 500$	$425 - 300$
IV	$0.40 - 0.30$	$500 - 360$	$300 - 215$
V	$\leq 0.30$	$\leq 360$	$\leq 215$

Source: SNI 03-3527-1994.

The specific objectives of this research are: (1) To obtain the physical and mechanical properties of coconut-timber as a construction material for timber house and to identify the strength class of coconut-timber; (2) To design a earthquake-resistant timber house model made of coconut-timber; and (3) To test the performance of the coconut-timber house under earthquake load.

This research is one of the applications of building construction engineering to mitigate earthquake disaster through the design of timber house that is safe for earthquake prone areas. This research is important as an effort to utilize and to increase the value of local coconut-timber waste from unproductive coconut trees to be used as a construction material to build earthquake-resistant timber house. Moreover, results of this research are expected to support the empowerment of local economy by utilization of potential sustainable local natural resources.

## Research Method

Research methods (**Figure 1**) comprise of laboratory tests, design of coconut-timber house prototype that is resistant to earthquake and performance test of the prototype of coconut-timber house under earthquake load.

The experimental stage in the laboratory consists of physical and mechanical properties tests which cover moisture content test, density test, tensile test parallel to grain, compression test parallel to grain, compression test perpendicular to grain, shear strength parallel to grain, flexural test, and toughness (**Figure 2**). Samples for the tests were obtained from unproductive

coconut trees from Minahasa Selatan region in North Sulawesi. Total numbers of samples were 791. Experimental tests were performed at the Civil Engineering Material Testing Laboratory and Mechanical Engineering Material Testing Laboratory, Manado State Polytechnic. Test methods were based on the American Standard Testing Material (ASTM) D143-09. Results from this experimental stage were used as references in design stage of a 6m x 6m model of coconut-timber house.

The design stage of the prototype includes the drawing of design plan of the timber house and calculation of coconut-timber structural elements. The design stage was performed in

accordance to design principles and standards of building model by considering earthquake load. Preparation of dimensions of structural elements which consist of beam, column, floor panel, wall panel and roof was performed after the structural analysis calculation.

The next stage was testing of the performance of coconut-timber house prototype. Performance test of structure was done by analysis of the structure under earthquake load with simulation of structural model. The software used for the simulation was ETABS (Structural software for building analysis and design).

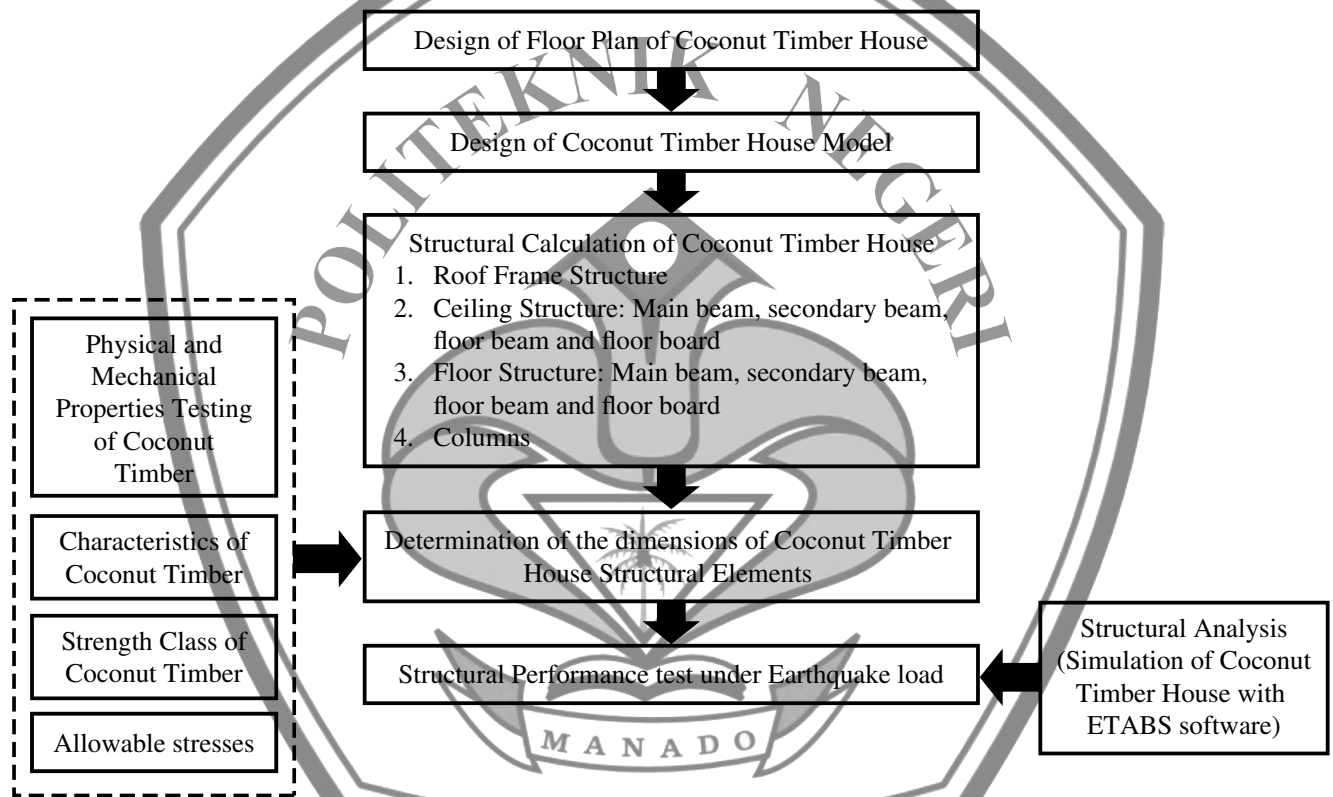


Fig. 1. Research Method



Fig. 2. Mechanical properties tests of coconut-timber at the Material Testing Laboratory, Manado State Polytechnic

## Results

### A. Characteristics of coconut-timber as timber house construction material.

The experimental test results are presented in **Table 2**.

According to the categories of timber strength classification in SNI 03-3527-1994, the strength class of coconut-timber is as follow:

- The air-dry density is in the range of strength class I and II, therefore can be used as structural timber, which usage requires calculation of load.
- The compressive strength parallel to grain is in the range of strength class III, therefore can be used as non-structural timber, which usage does not require calculation of load.
- The flexural strength is in the range of strength class III to IV, therefore can be used as auxiliary building material or temporary building.

Table 2. Test results from the mechanical properties tests in the laboratory

No.	Characteristics of coconut-timber	Test result
1	Modulus of Elasticity (kg/cm <sup>2</sup> )	67000
2	Flexural strength (kg/cm <sup>2</sup> )	458.66
3	Compressive strength parallel to grain (kg/cm <sup>2</sup> )	399.3
4	Compressive strength perpendicular to grain (kg/cm <sup>2</sup> )	179.79
5	Shear strength parallel to grain (kg/cm <sup>2</sup> )	65.13
6	Density (gr/cm <sup>3</sup> )	0.9
7	Moisture content (%)	15.95
8	Tensile strength – parallel to the grain (kg/cm <sup>2</sup> )	44760.1
9	Toughness (kgf)	424.74

### B. Structural Design and Floor Plan of Coconut-timber House.

Results of structural design of a coconut-timber house with a floor plan size of 6 m x 6 m are shown in **Figure 3**.

The result of the design of a coconut-timber house model is shown in **Figure 4**.

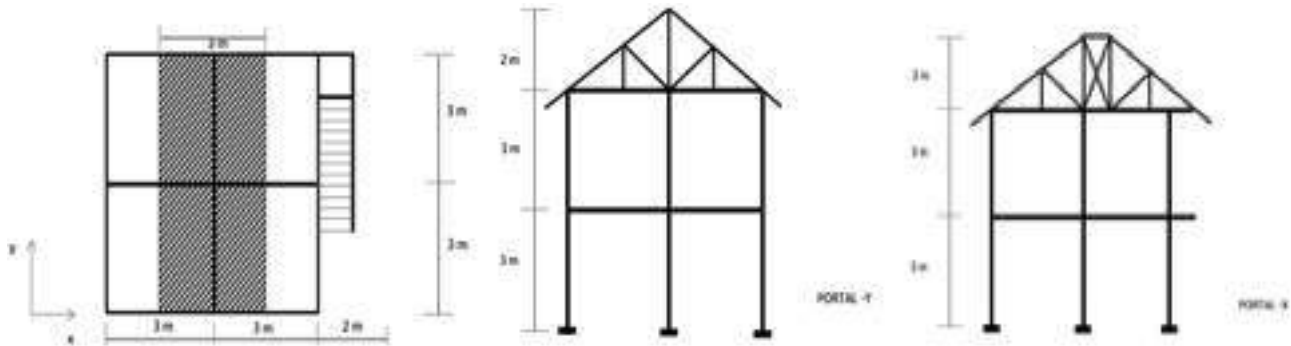


Fig. 3. Design of coconut-timber house: (A). Floor Plan; (B). Portal Frame X-axis; and (C). Portal Frame Y-axis.



Fig. 4. Design drawing and model of coconut-timber house.

### C. Calculation of the dimensions of Structural Elements of Coconut-timber House

Structural calculation of coconut-timber house includes roof frame structure, ceiling structure: main beam, secondary beam, floor beam and floor board, floor structure: main beam, secondary beam, floor beam and floor board, and columns. Determination of the dimensions of coconut-timber house structural elements was performed in accordance to design principles, standards and implementation methods building model construction by considering earthquake load. Design results of dimensions of the coconut-timber house structural elements are presented in Table 3.

### D. Structural Analysis of coconut-timber house structure under earthquake load.

Structural performance test is done by analysis of structure under earthquake load with simulation of structural model. The

software used for this simulation process is ETABS (Structural software for building analysis and design). The sway mode caused by earthquake on the frame structure of coconut-timber house generated by ETABS software can be seen in Figure 5. Result from the structural analysis of the frame structure of coconut-timber house under earthquake load with ETABS software shows that the construction is safe under earthquake load.

Table 3. Calculation result of the dimensions of coconut-timber house structural elements

No.	Construction	Element	Dimension
1	Roof truss	Compression	b=8 cm and h=12 cm
		Tension	b=8 cm and h=12 cm
2	Ceiling	Main beam	b=10 cm and h=18 cm
		Secondary beam	b=10 cm and h=18 cm
		Floor beam	b=5 cm and h=10 cm
		Floor boards	b=25 cm and h=2,5 cm
3	Floor	Main beam	b=15 cm and h=20 cm
		Secondary beam	b=15 cm and h=20 cm
		Floor beam	b=5 cm and h=10 cm
		Floor boards	b=25 cm and h=2,5 cm
4	Upper columns		b=15 cm and h=15 cm
5	Lower columns		b=15 cm and h=15 cm

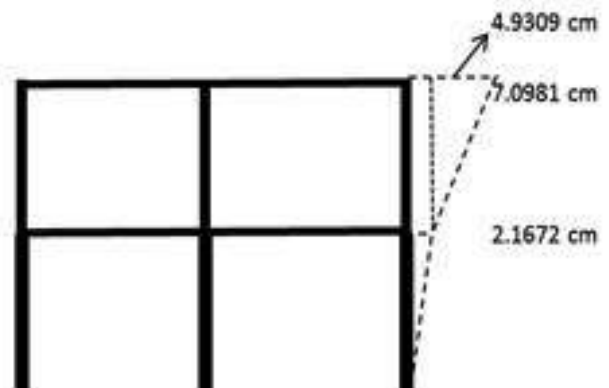


Fig. 5. Sway mode due to earthquake load acting on the frame structure of coconut-timber house (generated with ETABS)

## Conclusions and Expected Outcomes

Results of laboratory testing that conform the SNI 03-3527-1994 classification, the strength class of coconut-timber can be used as structural construction timber, of which usage requires the calculation of load; as a non-structural construction timber, of which usage does not require the calculation of load; and as a temporary construction material.

The determination of the dimensions of coconut-timber house structural elements was performed based on the experimental results from the laboratory tests of the physical and mechanical properties of coconut-timber. The prototype of coconut-timber house was built based on the design and structural analysis followed by structural performance test against earthquake load using ETABS software. Results from the structural analysis of the coconut-timber house frame structure under earthquake loading using ETABS software show that the house is safe.

Results from this research are expected to support the beneficial usage of the potentiality of coconut-timber as a construction material for timber house in an effort to mitigate the risk of earthquake hazard in North Sulawesi.

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