

## **Joglo House Structural Responses to Earthquake (Case Studies: Yogyakarta)**

Aris Ryant Kurniawan<sup>1</sup>, Putu Ayu P. Agustiananda<sup>2</sup>  
Department of Architecture, Universitas Islam Indonesia  
<sup>2</sup>Email: 085120101@uui.ac.id

**ABSTRACT:** *Indonesia is one of the archipelago country that located on earthquake prone area, it is because our country was on the ring of fire area, which this case Indonesia has many vernacular architectures that could be threaten by the earthquake. One of the location that has ever been stricken by the earthquake in Indonesia is Yogyakarta in 2006, and the case here so many joglo house in Yogyakarta that affected by the earthquake destroyed, but some of it still stand firmly and still as it is in the present. The structural response of joglo house seems to be possibilities that cause it and could withstand the earthquake. Because of that we need to analyze some literature of structural response of joglo house to the earthquake force. The approach taken in this research is by using systematic literature review and meta-analysis methods as prove by analyze 10 journals and researcher's observation to the research location. From all of that data there will be found several indications that affect the response of joglo house structure to the earthquake, after that is expected to find what can be developed and recommended in the future research and designing. In this study case, joglo house research as the analytical subject, and structural responses of joglo house to the earthquake forces as main object.*

**Key word:** Joglo house, Yogyakarta, Earthquake, Structural Responses

### **INTRODUCTION**

In Indonesia, the phenomena of natural disasters are often happened and it is already annually could be faced. It is because Indonesia was one of the country that on the high potency of natural disaster area, especially the volcanic and tectonic activity, it is because Indonesia was on the line of the ring of fire, which is the activity of volcanic and tectonic are actively high. It is proven on the record of natural disaster on 2006 and 2010 that Yogyakarta have been stricken by earthquake and Mount Merapi eruption that also cause tectonic activity. In this case here Yogyakarta in 27 may 2006, especially at the southern part of Yogyakarta, stricken by earthquake that cause so many *joglo* house destroyed, but there are still some of houses that still stand firmly. It means the feature of *joglo* house structure behavior has various response to the earthquake force. The resilience of *joglo* house is really needed in order to be able confront the upcoming earthquake that unpredictable but we still have to ready to deal with that. Considering of that, it is necessary to find out the factors that affect it response by doing this research. By finding the 10 journals that related to the *joglo* house structure response to the earthquake, I have to analyze the research by finding the factors that could cause the response, and expected that this research could be useful in inventing new ways and improve the researches to the *joglo* house structure response to earthquake.

### **METHODS**

This study approach by using systematical literature review methods by findings several relevant researches. It processes by identifying and critically appraising relevant research, in other way for collecting and analyzing data from research that have been found (Liberati et al., 2009). That process proven by this research in findings 10 journals that relevant to this research theme about structural response of joglo house to the earthquake. The source of the 10 journals that have been found are from the academic journals compilation website, and by inputting the keyword of joglo house, Yogyakarta, earthquake, and structural response.

In proceeding the next step after collecting the data, analyzing step to identifying the data from 10 journals by conducting meta-analysis. This method of analysis is to compare by combining results from different research, in order to find the disagreement, identify the research patterns, or relate the context from different studies on the same topic (Davis et al., 2014). The method by meta-analysis that I used in this research was applied in a way of using the comparison table to specified the 10 journals systematically and identify in critical way of thinking to conduct the literature reviews by using four steps of process; first step that have been applied is by Designing the review. By questioning what review should be conduct in this research, what is the literature review that would be most powerful and has greatest contribution to the research topic. The consideration of this this step is to find out how could the literature reviews will be interesting to both the author and readers (Snyder, 2019).

The second step is to conducting the review by specified the researches that have been collected by deciding the topic, methodology, result of each journals and to make sure the specified data are inclusion of my research's criteria. In this step I create the table of the journals applied the specified data that I have been read and ready to be processed in analysis step (Snyder, 2019).

The third step is doing the Analysis to the specified data based on the research purpose and question the have been conducted. In this case the analysis is to find the factors what makes the joglo structure could response on earthquake differently (Snyder, 2019).

And the last step is to writing the review that have been identified systematically in the previous step. This method expected to gives the reader chances on assessing the quality and trustworthiness of the finding from the 10 Journals that have been found (Snyder, 2019).

After doing all of the step above, it is expected finds the factors that affect the structural response of joglo house to the earthquake force as the results, and all of the factors supposed to be concluded into the discussion. and after that the conclusion expected could be used as the improvement and recommendation of joglo house structural response to the earthquake research and invented in advance building design especially joglo house.

## RESULT

The structural response of Joglo house to the earthquake force based on the analysis from the 10 journals and several researchers could be described in several major topics that explain about the response of Joglo house structure based on its form and its construction, also the building resilience based on calculation analysis, and there also explanation about the damage of Joglo house caused by the earthquake not just because its structure, but also the natural environment factors and human factors that caused the durability of the material of the Joglo house. Reduce methods that used in this research can be seen in the table of the 10 Journals research comparison, **Table 1**.

In article #1 titled Perilaku Rumah Tradisional Jawa "Joglo" Terhadap Gempa, authorized by Prihatmaji, Yulianto P., 2007, the main topic that discussed in research is the resilience of joglo house to the earthquake classified by its building form. The topic that related to the deformation of the joglo structure after the earthquake also explained in article #4, article #5, and article #8.

And the Article #8, In this research, the calculation by doing experimental method also applied just like in the Article #1, the form and proportion is applied to the design experiment on shelter that could handle the earthquake forces. From the related research on joglo form and proportion on response to the earthquake forces mostly explained by Prihatmaji, Yulianto P.

The external factors that mentioned in previous research, about the environment and maintenance that causing the response of joglo structure to the earthquake force. These explained in Article #9 and Article #10, but this discussion also explained in article #7 titled

Building resilience in heritage district: lesson learned from Kotagede Yogyakarta, Indonesia, authorized by Rahmi, Dwita Hadi, 2017, her research explained that the maintenance on the joglo house is needed, also as anticipation in reconstructing Kotagede heritage building after the earthquake.

And the most important topic from several Articles were about the construction of the joglo house itself. The joint structure of the joglo house really have the most influence to the response of the joglo house, in Article #1 it mentions the form and proportion of the structure, and calculate by doing the experiment on the *rong-rongan* structure, where the *rong-rongan* has complexity in joinery, and that affect the strength of the house when confronting the lateral forces. In Article #3 it mentions about the interlocking system and the knockdown on the roof of joglo. And in Article #4, Article #5, and Article #6 it has similar topic to the Article #1, where it says about the durability of the house depend on the connection of the structure with its Mortise-Tenon structure. And finally all the articles that listed on the table below based on its topics, methods, and results are summarized in **Table.1.**

**Table 1.** Table list of articles summaries

Articles	Title	Author	Topic	Method	Result
#1	Perilaku Rumah Tradisional Jawa "Joglo" Terhadap Gempa	Prihatmaji, Yulianto P., 2007	The Durability of "Omah Joglo" classified by its form	By using the experimental of laboratory scale, and using the control variable to find the reaction of the actual phenomenon.	The stability, deformation, and energy dissipation of the experimental model.
			The Main Structure of "Omah Joglo"		Behaviors of the main structure of the "Omah Joglo" based on the scale of the earthquake forces.
			The reaction of "Omah Joglo" in responding the lateral forces.		Behaviors of the main structure of "Omah Joglo" based on the construction technique that used and the space configuration of the house.
#2	Respon Pendopo Joglo Yogyakarta Terhadap Getaran Gempa Bumi	Maer, Bisatya W., 2008	Theory of earthquake and the building response on it.	By using qualitative methods and compare between two "Omah Joglo" response to earthquake based on the structure main support and based on static equivalent earthquake load.	The analysis of comparison between two "Omah Joglo" with the base-isolator, attenuation, and flexibility of building structure approach.
			The analysis of static equivalent earthquake load		
			Attenuation, flexibility, and base-isolator of the building structure		
			The main structure of "Omah Joglo"		

Articles	Title	Author	Topic	Method	Result
#3	Interlocking System Pada Konstruksi Knock Down Bangunan Tradisional Jawa Tajug Sebagai Teknologi Responsif Gempa	Komala Dewi, Nitih Indra; Pratiwi, Sri Novianthi; Fajria, Mei Nisa, 2019	- The Javanese Tajug Architecture	By using Depictive descriptive method based on several aspects; form, texture, and material, on <i>Tajug</i> Javanese traditional house	- The Interlocking system on Javanese traditional house structure were responsive technology to the earthquake forces.
			- The theory of structural system of earthquake building resistance and its theory.		The wooden structure of Javanese traditional house was supported by several aspects; flexibility, elasticity, stability, attenuation, ductility, wooden hyperelastic character, and construction
			- The behaviors of traditional Javanese house on earthquake response (Prihatmaji, 2007)		
			The <i>knock down</i> component on <i>Tajug</i> Javanese traditional house.		
Articles	Title	Author	Topic	Method	Result
#4	Seismic vulnerability on structural proportion of traditional Javanese wooden houses (Joglo)	Prihatmaji, Yulianto P., 2015	The 29 joglo house including the 5 royal joglo house investigation and its damage degree after earthquake of yogyakarta in 2006	The method that has been used in this research are by doing sampling observation on the object and by doing empirical methods by proofing by coming to the site and doing direct measurement to find the data	The dimensional measurment of Joglo house including the vertical and horizontal structure of the Joglo house
			The structural proportion of the Joglo Houses		The estimation of vulnerability of Joglo house after the earthquake based on the structural proportion of the Joglo
			The vulnerabilitiy of Joglo house to earthquake		

## Praktek Arsitektur di Era Kelaziman Baru

Articles	Title	Author	Topic	Method	Result
#5	An Investigation of Traditional Javanese Wooden Houses 'Joglo' Damaged during the May 2006 Yogyakarta Earthquake, Indonesia.	Prihatmaji, Yulianto P.; Kitamoru, Akihisa; Komatsu, Kohei, 2015	The explanation of earthquake data on Yogyakarta in 2006, May 27 and the data of damaged Joglo houses.	This reasearch using the qualitative methods by findings the literature studies about the Joglo houses structure and by using empirical methods, doing direct observation to the location and by using his own previous research about joglo house vulnerability on earthquake forces.	The dimensional proportion to its joint in main column and the position in height just like the common traditional carpenters rule, it does'nt affect the building plans.
			The Typology of Javanese wooden houses and its structure details.		There are four level of damage, which the side structure relatively weak and the core structure could withstand the whole Joglo building.
			The detailed observation on the damaged building based on the area that strict by the earthquake in Yogyakarta, 2006.		The realationship between the vertical section area of the main column and the horizontal area of the core structure has strong relationship. The smaller ration, the higher the extensive damage.
			The structural vulnerability and the principal damage mechanism including the damage level on the Joglo house structure and its connection with its proportion.		These proven the structural proportion significantly contributes to simple estimation of earthquake resistance performance of Javanese wooden house. There is little deterioration was found among the inspected Joglos.
Articles	Title	Author	Topic	Method	Result
#6	Santen-Fuse as an Earthquake Damper for Pendopo Joglo	Maer, Bisatya W.; Pudjisuryadi, Pamuda, 2015	The explanation of Joglo House construction and its resilience to the earthquake force based on existing literature review and the performance of Santen in Joglo house construction mechanism.	By using experimental quantitative methods, this research use the SAP 2000 program as the model for structural simulation of Joglo house response to earthquake force. And by using the empirical methods of researcher previous findings.	The effect of Santen-fuse changing rather than the ordianry Santen increase the performance of Joglo main structure in earthquake response.
			The observation on Santen fuse of Joglo house, with the experimental modeling with SAP 2000 program.		The bolt tightening application for SANTEN-fuse is still limited to this research and cannot be generalized for actual use yet. Further research should be conducted to formulate the conversion table of bolt torque moment (the result of bolt tightening with torque wrench) to axial force. Because of this research based on the secondary literature data, so this research still can be developed furthermore.

## Seminar Karya & Pameran Arsitektur Indonesia: Sustainability in Architecture 2020

Articles	Title	Author	Topic	Method	Result
#7	Building resilience in heritage district: lesson learned from Kotagede Yogyakarta Indonesia	Rahmi, Dwita Hadi, 2017	The reconstruction of Kotagede heritage building after the earthquake.	This research are using the qualitative methods by using existing literature studies, direct observation site survey and semi-empirical methods by finding the existing research about the related topic.	The reconstruction of six traditional houses. In this case, the selection of which houses needed to be reconstruct was helped by OPKP as the representation of Kotagede community
			The resilience of Kotagede after the earthquake.		Post-disaster recovery program of a heritage district is not a short time program, but it needs yearly to bring it back to the normal condition or even better. Building the resilience toward disaster can be achieved if there are voluntarily commitment and willingness among stakeholders (local community, government, private agencies, university, and other parties) to work together in coping the disaster.
Articles	Title	Author	Topic	Method	Result
#8	Joglo Architecture Development for Post Earthquake Temporary Shelter	Alvin, Theodorus; Gunawan, Yenny, 2015	The Joglo house anlysis as the temporary shelter in structurtal aspect and its earthquake resilience application on the shelter	The methods used in this research is by doing experimental methods and finding the literature studies. Which focused on design that adapt the ability of Joglo knock-down system and its application in temporary shelter.	Based on the temporary shelter design prototype I and II, The Joglo house has potency in aspect of earthquake resilience building.
			The adapation of Joglo house into the temporary shelter design		
			The prototyope of temporary shelter I and II		

Articles	Title	Author	Topic	Method	Result	
#9	Penilaian Kondisi Fisik Rumah Tradisional Joglo di Kelurahan Jagalan, Kotagede	Kusuma, Gianni Angger, 2018	The heritage conservation provision based on the UU No. 11 2010. and its connection to Jagalan, Kotagede heritage conservation needs after earthquake 2006	This research used the qualitative method, by doing descriptive research and analytical qualitative. And literature studies as the guide of focus in doing the research on the field in order to have accurate research.	The condition of the Joglo houses in Jagalan after the earthquake has some factors, from materials, the environment, and also the maintenance that has been done in several times.	
			The physical condition comparison of three Joglo house in Jagalan that have been already analysed and do the assessment on it.			
Articles	Title	Author	Topic	Method	Result	
#10	The Vulnerability of Javanese Traditional Joglo Houses due to the Homeowner-driven Rehabilitation and Recovery before and after The 2006 Yogyakarta and Central Java Earthquake	Khaerunnisa; Sawaki, Masanori; Shibata, Yu, 2012	The vulnerability of Joglo house in response of earthquake and the weakness of protection policy in maintenance.	The methods that used in this research by qualitative methods, with the literature studies and site survey data findings. And by doing semi-empirical methods, which take data from others existing researches.	Found that the condition of Joglo house has been degraded even before the earthquake occurred, and its change of structural form in the process of the earthquake.	
			The behavior of damaged Joglo house and after the recovery.			Lack of knowledge and understanding of Javanese building recovery by the masons could give further threat in preserving originality of the joglo house especially after massive disaster.
			Impact of the recovery process of the joglo house in response to earthquake.			

Source: Ryant K., Aris, 2020.

## DISCUSSION

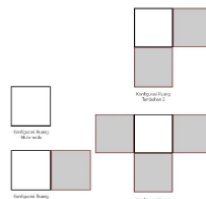
- a. The Response of Joglo house based on the Form and the dimension proportion of the house  
Article #1, Article #4, Article #5, Article #8

In Article #1 explain there are several forms of Javanese house, Panggangpe, Kampung, Limasan, and Joglo, and this is shown in diagram of **Figure 1**, it shows the Joglo house here and the other type of Javanese house, has the same reaction that the structure was shifting by the lateral forces of the earthquake, and the different explain in this article based on the diagram, the load bearing of the structure also affects differently, more weight the load more damage to the houses, also the houses.

Gaya Batang	Jenis Rumah Tradisional Jawa				
	Panggung	Kampung	Limasan	Joglo	Talang
Atlitur Beban Aksial					

**Figure 1** Joglo houses reaction to the earthquake lateral force and self-weight source: Prihatmaji, 2003

In article #4 explain about the dimension and proportion of the Joglo house structure based on the traditional carpenter’s rule, it means like the ration between vertical section area from the main column with horizontal area of the core structure and level of damage, if the ratio is small the damage is more extensive. It can be described the vertical dimension could be affected by the gravitation and the load bearing of the house, which if it higher the structure should be wider in order to prevent the lateral forces damage. The Article #5 also has same explanation about the vertical and horizontal structure of Joglo house but it has advanced explanation to the roof connection. The Article #8 has the development methods from Joglo house to the experimental and it has concept based of standard minimal space development and modular space and applied it into developed Joglo house. Just like in **Figure 2** more modules or grid to the structure of the house, the strength of the structure will response well to the lateral forces of earthquake.



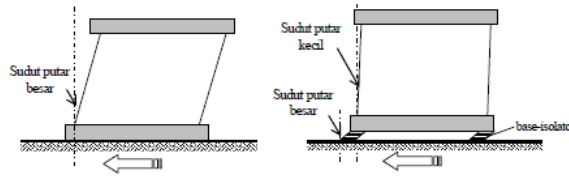
**Figure 2** Development of space layout based on flexibility concept Source: Alvin, 2019

b. The Response of Joglo House Based on Components Article #2, Article #9, Article #10

In Article #2 it is explain the innovative component that can be applied in joglo house structure, the base-isolator which in principle, base-isolator trying to "separate" the building from the movement horizontal foundation by installing equipment the isolator between the column and foundation. Base-isolator has a very flexible nature of style horizontal, but able to withstand the weight of the building well. With these very flexible properties then when the earthquake shifts the foundation, base isolator doing horizontal deviations back and forth which is large, thus the earthquake vibrational energy from the soil diverted by an insulator so it is not propagate to the building structure. In **Figure 3** shown that the components of base-isolator could reduce the shifting of the main structure of the house when stricken by the lateral forces, or it



could be said the base-isolator as substitute shifter so it could reduce the damage when the earthquake comes.



**Figure 3** Without base isolator (Left) With Base Isolator (right)  
Source: Bisatya, 2008

Based on this articles, to assess the Joglo house by doing the components of structure assessment in **Table. 2** below, could be concluded that each component in materials quality has range value between 3.9-4.6 which is it has good quality based on the value in **Table. 3**, it is also affected by the maintenance intensity which it has range between 3.7-4.9 which is it means it has often done the maintenance to each component and it makes the construction condition of the house has range between 3.8-4.4 which is its good and proper.

**Table 2** Table assessment of Omah UGM

Assesment type	Public Area		Semi Public-Private Area						Services Area					Score	Average	
	Pendopo	Longkangan	Pringgitan	Kiwa	Tengah	Tengen	Kiwa	Tengen	Gandhok	Gadri	Pawon	Pekiwan	Kamar pembantu			Sepen
House Construction Condition																
1. Upper Part	3.3	0	4.3	4.3	4.3	4.3	3.6	3.6	4.3	4.6	4.6	4.6	4.6	4.6	50.4	4.2
2. Middle Part	5	0	4	4	4	4	4	4	3.6	3.3	3.3	3.3	3.3	3.3	45.8	3.8
3. Bottom Part	4.2	5	3.6	4	4	4	5	4	5	4.6	4.6	4.6	4.6	4.6	57.2	4.4
Material Quality																
1. Upper Part	4	0	5	5	5	5	5	5	3.6	4	4	4	4	4	53.6	4.5
2. Middle Part	4	0	4.6	4.3	4.6	4.3	4.6	4.6	4.3	3	3	3	3	3	47.3	3.9
3. Bottom Part	4.2	5	4	4.6	4.6	4.6	5	5	5	4.6	4.6	4.6	4.6	4.6	60.4	4.6
Maintenance intensity																
1. Upper Part	3.3	0	3.6	3.6	3.6	3.6	3.6	3.6	3.6	4	4	4	4	4	44.5	3.7
2. Middle Part	5	0	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	55.6	4.6
3. Bottom Part	4.6	5	5	5	5	5	4.6	5	5	5	5	5	5	5	64.2	4.9
Condition (Acceptable/Unacceptable)	5	5	5	5	5	5	5	5	5	5	5	5	5	5		

Source: Ryant K., Aris, 2020

**Table 3** Value table for joglo house table assessment

House Construction Condition	Material Quality	Maintenance intensity	Condition (Acceptable/Unacceptable)	point
Good	Not changed	Very often	Full proper	5
Quite good	Not changed, Less good quality	Often	proper	4
Enough	Changed, Good quality	Quite often	quite proper	3
Quite bad	Changed, Enough quality	Not often	less proper	2
Bad	Changed, Bad quality	Never	not proper	1

Source: Kusuma Angger, 2018

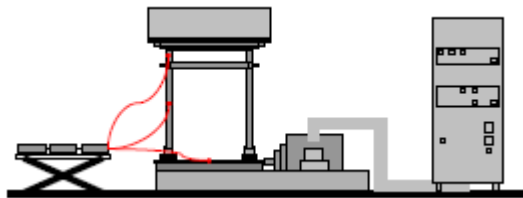
And in Article #10 which is can be related to the Articles #9 which explained about the maintenance on the Joglo house material itself, which in this articles

explained about the recovery maintenance, but this is also affect the choice of material quality during the maintenance which is affecting the components of the house.

c. The Response of Joglo House Based on Calculation

Article #1, Article #6, Article #8

The articles above are explaining the respond of Joglo house based on Calculation that have been done by Experimental Methods. In Article #1 The term stable on the model, in this discussion, means the model is visually visible and does not vibrate. The term unstable shows the model visually visible vibrate or sway. The term deformation shows that the model is changing shape, leaning to the right or left. The term energy dissipation, indicates that energy has taken place in certain parts to reduce vibration or called damping. This calculation has been done by doing experiment on rong-rongan structure with horizontal flip table like in **Figure 4** below.



**Figure 4** Experimental scheme on *rong-rongan* structure assessment with horizontal flip table

Source: Prihatmaji, 2007

In article #8 the calculation by doing calculation with experimental methods by developing the standard Joglo house design with the new modular space concept development because basically Joglo house could be developed in structural and space aspect. This calculation by experimental method develops the potential of Joglo house in order to calculate and find the optimal resilience of the house responding the earthquake, and it also open the way to keep develop the idea of the Joglo houses in the best performance.

d. The Response of Joglo House Based on External Factors (Maintenance, Enviroment)

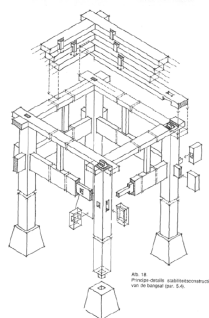
Article #7, Article #9, Article #10

In Article #7 it is explain the indication of Joglo house resilience in responding the earthquake affect based on the maintenance and its environment too, like it can be judged from the effective collaborative action between the local community and outside parties. Also in article #9 explain about the maintenance of Joglo house in responding the earthquake by doing the assessment on its components material quality with the comparative tables explained in previous category. And in Article #10 said the cause of Joglo house resilience in responding the earthquake because of the bad maintenance before the earthquake happened, so many materials that degraded and not maintained well.

e. The Response of Joglo House Based on Construction

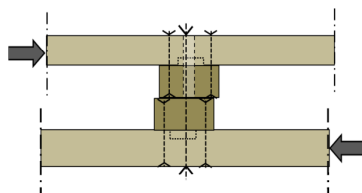
Article #1, Article #3, Article #4, Article #5, Article #6

In Article #1 the rong-rongan structure just like in the **Figure 5** below, it has response to the earthquake lateral forces, which is affected by the acceleration of the vibration, based on the calculation experiment that has been done, it has been deformed on the whole joint and energy dissipation occurred on soko guru, sunduk-kili, blandar-pengeret, and the joints between those three.



**Figure 5** The rong-rongan structure  
Source: Leedam, 1969

In Article #3 it explains about the interlocking and the knockdown system on the corner of each saka guru, just like in **Figure 5** above, the complexity of the joints that also give the flexibility and strength to the main structure of house. In Article #4, and Article #5 also explain similar things with the Article #3 about the connection between the saka guru and the others components. And in Article #6 it is about the addition of components to the joint of santen with santen-fuse like in **Figure 6** below, the santen-fuse will be the shifting device when the lateral forces of the earthquake strike the house.



**Figure 6** Santen-fuse shifting position  
Source: Maer, Bisatya W., 2015

## CONCLUSION AND RECOMMENDATION

The joglo structural response to the earthquake in Yogyakarta based on the analysis of the comparison from 10 journals I find several indications. I report the result from the analysis that aimed to classify the responses, it has been summarized below:

1. The Indications of the joglo structural response mainly based on the internal (Components and material) and external factor (maintenance and environment).
2. Based on the Indication classification in this research, the calculation that done by experimental method could have applied the internal and external factors as control variable, in order to find the optimal result on joglo structure response.
3. Most of the research just using one-sided indication, where between internal and external factors are highly related each other.
4. It can be concluded that between each Indications are connected each other based on the urgency connection of the structure reaction between form and dimension, components, calculation, and maintenance.
5. The joint of the house are the most components that influence the response of the joglo house to the lateral forces.
6. The structure of the house was influenced by the external factor and the other indicators that have been found, which it makes the deformation after the earthquake more impact.

There are several recommendations that could be used as future research and advance design on joglo structure:

1. All of the factors should be included in future research as the control variable for finding the optimal result on joglo structure response on the earthquake forces.
2. In applying the Indicators as the control variable, followed by experimental method that could be direct assessment, could bearing innovation on optimal design of joglo structure.
3. There could make the step of analysis from the four indications that can be found into analytical research process in finding the optimal response of the joglo.

### References

- Alvin, T. (2019). JOGLO ARCHITECTURE DEVELOPMENT FOR POST. *Jurnal RISA*, 205-221.
- Dewi, N. I. (2019). Interlocking System Pada Konstruksi Knock Down Bangunan Tradisional Jawa Tajug Sebagai Teknologi Responsif Gempa. *JAZ Vol. 2*, 147-159.
- Hadi, D. R. (2017). Building resilience in heritage district: lesson learned from. *IOP Conference Series*, 1-7.
- Kharunnisa. (2012). The Vulnerability of Javanese Traditional Joglo Houses due to. *Journal of International City Planning*, 729-739.
- Kusuma, G. A. (2018). PENILAIAN KONDISI FISIK RUMAH TRADISIONAL JOGLO. *Jurnal Arsitektur KOMPOSISI, Volume 12*, 141-152.
- Maer, B. W. (2008). Respon Pendopo Joglo Yogyakarta Terhadap Getaran Gempa Bumi. *DIMENSI TEKNIK ARSITEKTUR Vol. 36*, 1 - 9.
- Maer, B. W. (2015). SANTEN-fuse AS ANEARTHQUAKE DAMPER FOR PENDOPO JOGLO. *DIMENSI – Journal of Architecture and Built Environment, Vol. 42*, 1-8.
- Prihatmaji, Y. P. (2007). Perilaku Rumah Tradisional Jawa “Joglo” Terhadap Gempa. *DIMENSI TEKNIK ARSITEKTUR Vol. 35*, 1 - 12.
- Prihatmaji, Y. P. (2015). An Investigation of Traditional Javanese Wooden Houses ‘Joglo’ Damaged. *NA*, 1-18.
- Prihatmaji, Y. P. (2015). Seismic vulnerability on structural proportion of traditional. *Procedia Environmental Sciences 28*, 804-808.