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Rethinking the Traditional Architecture Based on Building Science Technology Perspective: How Does Javanese Traditional Architecture Form the Acoustic Behavior of Gamelan Music? (A Case Study of Srimanganti Bangsal of Keraton Yogyakarta)

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Abstract: This research discusses about rethinking traditional architecture by extending the studies about the perspective on building science technology, especially the acoustic. The objective of this study is to research about how Javanese architecture (Joglo building) in treating music with Javanese character. In addition, it aims to identify significant element of the building in treating Javanese music between the column and Tumpangsari (name of Javanese unique multi beam frame). The sample of this research is bangsal srimanganti in the complex of Keraton (Sultan Palace) of Yogyakarta. The character of Javanese gamelan music is limited to the characteristics of the frequency and the sound level. The methods of this research are observation for data gathering, model circulation and data comparison. The data collected are primary and secondary data. Primary data are building materials, activities and layout while secondary data are the sketch and cuts of Bangsal Srimanganti. All the data became the materials of simulation using ECOTECT 2011 Software. This simulation yielded data such as ray diagram and reverberation time in different frequency. The variations of reverberation time are compared between the original model with the empty model only using column and multi beam frame. The comparison was conducted with the assistance of SPSS Software with the reliability level up to 95% and the tolerance level of 5%. The comparison is seen from the value of significance and correlation. This research found that Javanese building treated the sound by bouncing and diffusing it. In addition, the research found that Tumpangsari and column are equally significant element in treating Javanese acoustic sound. However, Tumpangsari has higher values of correlation compared to the column. Thus, this research enhanced the importance of rethinking about traditional architecture knowledge from the perspective of building science and technology.

Key words: Acoustic, architecture, traditional, Java, Gamelan, Srimanganti, column, Tumpangsari

INTRODUCTION

Rethinking traditional architecture: Indonesia is a country with thousands of islands with a diverse ethnicities and cultures. One example of the architectural artifacts as the manifestation of traditional values is traditional building of Keraton or Sultan Palace. One of the sultanate buildings that still exist and well maintained up to this present is the Kraton of Ngayogyakarta Hadiningrat Sultanate. The previous researches about the building of Keraton Yogyakarta mostly discussed about the historical and symbolical aspects. Sugini (1993) conducted an unpublished research entitled "The Relationship of Shape Characters and Colors of Decorative Ornaments for Traditional Constructive Carving of Yogyakarta in the Tumpangsari (Javanese unique multi beam frame) and column in the Bangsals of Keraton Yogyakarta". At this present, traditional building has been icons that are replicated for modern functions. The new function is implemented mostly for the cultural function such as music performance and other similar activities.

This research will rethink traditional architecture by observing the acoustic performance. Acoustic performance becomes significant in relation to the duty of architecture as the venue of activity. The first sense of human being that research is the ear. The productivity or performance of the room occupants is also related with the performance of room acoustic. In relation to this topic (Reinten *et al*., 2017) reviewed 272 papers and mapped important relations of sound environment and the performance of the occupants. In the conclusion, they explained that room acoustic is the strategy to control the sound environment. This review is expected provide opportunities for the revitalization of traditional building for modern functions. This research also intends to identify to what extent the science technology aspects of building implemented in traditional architecture studies.

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Traditional building forJavanese music performance: According to Vitruviu's architecture theory, three components should be considered in designing. They are utility (function), firmness (power) and venusity (beauty). An architecture will be considered perfect when it has fulfilled the three components. A design of architecture will have different finishing depending on the kind and characters of functions that it holds. Similarly, the finishing for acoustic design of a performance room will vary depending on the type and character of the sounds that it covers. This also research for concert room that covers Javanese music (gamelan) that is different from opera musical performance.

Javanese music has existed, since, long time ago. Javanese music performance becomes regular show for the king in the palaces including Keraton Yogyakarta that has Bangsal (Joglo building without walls) used for room to perform Javanese culture and art. One of the cultural heritage that still exits and functions is Keraton Yogyakarta. The Keraton building as traditional building of Yogyakarta still play its function to run the tradition of sultanate up to this presents (Widyatmiko, 2014). Revianto referring to Yogyakarta History and Cultural Research Agency of Yogyakarta and Behrend in Sugini (1993) explained the complex of Keraton Yogyakarta is divided into five parts. They are Pagelaran with Bangsal Pengrawit as the sample of building. North Siti Hinggil, Bangsal Manguntur Takil and Bangsal Witono Pelataran Kamendhungan in the North (Bangsal Ponconiti) and the South (Bangsal Kemandhungan) North Pelataran Srimanganti (Bangsal Srimanganti) and South Trajumas (Bangsal Kemagangan). From all the available bangsals, Bangsal Srimanganti up to this present is still used as venue for gamelan music performance. Based on this, the object of this research is limited to the building of Bangsal Srimanganti.

Formulation of the problems:

- How does traditional architecture of Bangsal Srimanganti treat Javanese music
- Do the column and Tumpangsari as the special elements of Javanese traditional architecture significantly give impact to the acoustic of Javanese Gamelan music

Research objectives:

- To identity how Javanese traditional architecture (Bangsal Srimanganti) treated music with the characters of Javanese gamelan
- To identify the impact of elements in Javanese traditional building such as column and Tumpangsari (multi beam frame) in treating Javanese Gamelan music

The benefits of the research:

- This research may contribute insights and knowledge about traditional architecture that may solve the problem of Javanese music acoustic using the local wisdom
- This research may discover the important element in Javanese architecture, i.e., column and Tumpangsari that can be implemented for modern performance venue in Java
- This research discuss the necessity of traditional architecture enrichment from other disciplines especially building science and technology

Limitation of the research: This research is limited to the model for simulation. The simulation model is conducted through simplification of interior shape while simplification in the rafter order is conducted for shading and carving in the column and Tumpangsari. The character of Javanese gamelan music is limited to the characteristics of the frequency and the sound level.

Literature review

Architecture acoustic: Architecture is the medium of activity that should fulfil the sensory comfort of the users. Thus, an architect should understand the sensory comfort including the auditory sense affected by room acoustic (Sugini, 2015). In addition, an architect should also comprehend the important elements in designing a room. According to Sugini (2015) there are four elements of architecture acoustic, i.e., room acoustic sound isolation, noise and vibration of mechanical system and electronic sound system.

In the context of traditional acoustic research, the elements that should be considered are the room acoustic elements. Whereas the room isolation elements is disregarded because Javanese traditional building is not the type of building that can be isolated and this applies to the third element of room acoustic. It is because the complex of Keraton Yogyakarta is located far away that makes it free from sound pollution from electronic device and mechanical equipment. The fourth element is also not neglected because Javanese Gamelan music does not use the electronic sound system or artificial acoustic.

The treatment of room towards the sound: According to Sugini (2015) the quality of architecture acoustic is determined from the capability of a room to treat the sound in the space. Some sound behaviors that may influence the quality of acoustic comfort are reflection (bouncing) diffraction (deflection), diffusion and refraction. All happens in the room, except refraction that occurs in the open air or outdoor.

Reflection is a tendency of sound bouncing that may hit a particular field. This behavior is influenced by the shape of the plane, the type of material and the quality of the surface. The sound reflection will lead to the two natural phenomena of sound, i.e., echo and reverberation.

Reveberation or sound of buzzing: Sound of buzzing or Reveberation is a continuous sound caused by constitutive reflection in a closed room after the sound stops.

To achieve acoustic comfort, Reverberation Time (RT) is required. Reverberation Time (RT) is a tendency of time extension caused by sound reflection. RT is the time needed by the sound to fade out up to -60 dB. The determination of the accurate reverberation time is based on the activity, function, volume and the space. Every kind of music has the right RT for itself. This is influenced by the volume of the room. Since, Traditional Javanese building that becomes performance venue is almost an open air or outdoor space, there for the right RT of Javanese music or gamelan in this case have different characters.

From the four sound behavior mentioned above, only three that can be taken into account, i.e., reflection with the echo phenomenon, diffusion (sounds diffusion) because of contact with pointed plane and defraction (a behavior caused by a gap or fissure).

The characters of javanese music: Javanese music is more famous with the name of Javanese Gamelan. Javanese gamelan is a set of Javanese traditional music that is dominated by percussion, accompanied with wind and stringed instrument (rebab) and plucking instrument (zither). According to Hartono (2012), Javanese gamelan is included in the category of metallophone or bronze music instrument.

The various Javanese instrument is played by considering the aspects of sound quality. Those aspects are the loudness and softness of sound and resonance. The resonance of Javanese gamelan is related with the length of intonation, the quantity and the density of the sound wave. In addition, Javanese gamelan also considers the accuracy of tone or notation while playing the instrument (Hartono, 2012).

According to research from Suyatno gamelan has different level of loudness depending on the tone and kind of arrangement. The arrangement for the song "Gambyang Pare Anom" will produce the noise level in the stage for around 75 up to 97 dB while other arrangement can reach up to 105 dB. In addition to the level of noise, gamelan also has the frequency around 60-2550 Hz. Gamelan also has sound envelope or reverb time. Gamelan's source of sound majority is produced by hitting, so that, they produced sound will have short duration or length of time, since, the sound will directly fade out. Javanese gamelan in the case of the research has the RT between 0.5 sec up to 10.07 sec.

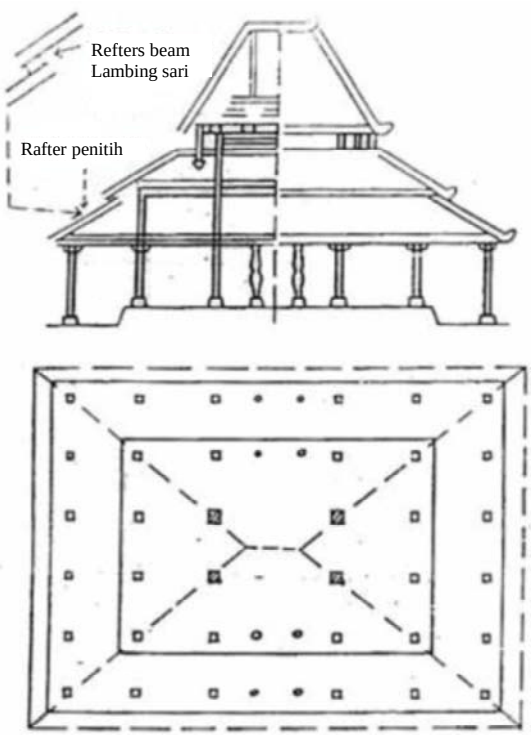

Fig. 1: Joglo Mangkurat

The architecture of javanese traditional: According to Purwani (2001), Javanese traditional architecture is categorized based on the shape of the roof, i.e., Panggangpe, Kampung, Limasan, Tajug and Joglo Joglo is considered as the perfect shape compared to the others because it has bigger size. The main feature of joglo is the use of Tumpangsari. Tumpangsari is the unique multi beam frame that support the roof construction. Another feature is the four pillars or column with main pillarsor main column in the center. There are 7 variation of joglo and one of them is Joglo Mangkurat.

Joglo mangkurat: This type of Joglo (Fig. 1) has almost similar shape with Joglo Pangrawit. The difference is located at the bigger size of joglo mangkurat and the emperan (semi verandah for public activities) or penitih which is not attached to the pillars of saka betung but connected to the lambing sari beam. It also has cylinder column located in the long side of the joglo. The arrangement of roof consists of three components, i.e., penitih, penanggap and brunjung.

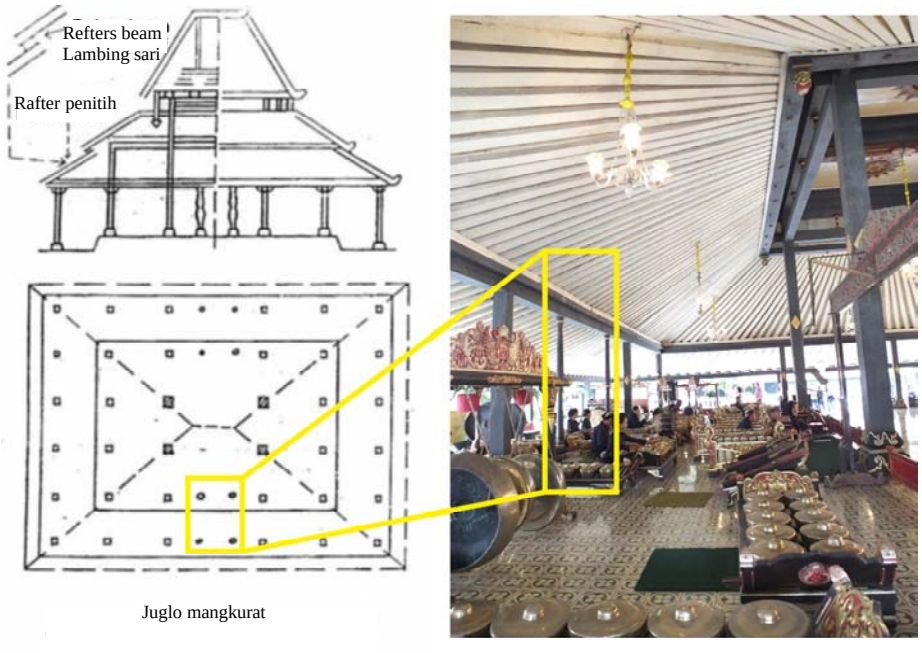

Fig. 2: Bangsal Srimanganti as Joglo Mangkurat in the roof part

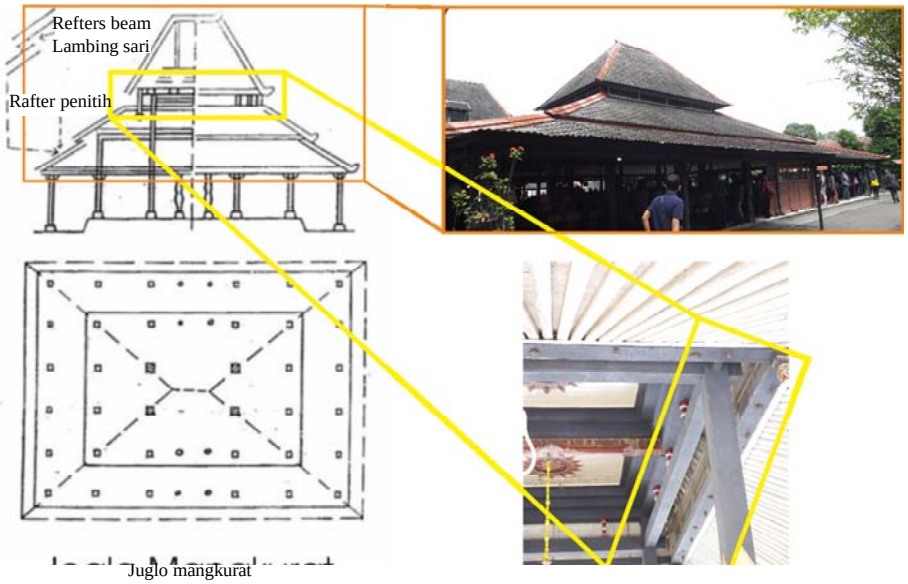

Fig. 3: Bangsal Srimanganti as Joglo Mangkurat with the existence of cylinder column

From the discussion about kind of Javanese traditional building, Bangsal Srimanganti of Keraton Yogyakarta (Fig. 2) is categorized as Joglo Mangkurat. This is concluded based on the similarity of roof shape and the construction of the building as well as the existence of cylinder column in the long side of the building (Fig. 3).

MATERIALS AND METHODS

Descriptive method is used to identify the existing interior model and the modification of interior model for column and Tumpangsari of Bangsal Srimanganti. In addition, this method is also used to identify the reverberation time (in sec) and the affecting aspects such

as kind of material, room volume, activity and noise level. The data were then used as input to conduct acoustic modelling simulation with the software of ECOTECT 2011. The data were then compared and examined using SPSS to determine which construction element between column and Tumpangsari that is significant for giving treatment about Javanese music acoustic in traditional Javanese architectural building.

Sampling method: Sampling method used in this research is non probability and purposive sampling. This research used Bangsal Srimanganti as the case or sample to examine the correlation between the type of building with the type of activities inside the building based on the topic of this research. This Bangsal (ward) is part of traditional Javanese building (Joglo Pengrawit) that is still used for conducting performance of Javanese culture with Javanese music.

Data gathering: Data gathered to fulfil the need of influence (independent) variable were rough data such as the interior picture of Bangsal Srimanganti both overview picture and details of the elements in the column and tumpangsari. The data were collected by observation and photography that was conducted when the venue is not used for performance with Javanese music. The data will be processed to be pictures of interior parts and sketch of the bangsal. The data were gathered to obtain dependent variable such as knowledge about kind of materials, room volume, activity, level of noise and reverberation time. The data were collected by conducting observation by using photo and sound meter application.

Method of analysis: To answer the first research question, this research use descriptive method by observing the simulation result using ECOTECT 2011 Software. The second research question about the significance of the relationship between elements of Tumpangsari and columns on Javanese gamelan music behavior is answered by using comparative method by comparing the result of observation in the simulation using the assistance of SPSS Software.

The comparison process use SPSS Software with 95% level of reliability and 5% of error level. If the significance value is <5% than the comparison can be considered accurate and the mistake could be tolerated.

RESULTS AND DISCUSSION

Descriptive analysis of acoustic behavior in Bangsal Srimanganti: To observe the acoustic behavior of the Javanese building, this research took Bangsal Srimanganti as the sample. The sound was reflected and diffused. As mentioned in the earlier theory of L.L Doelle (Sugini, 2015) a room can treat the sound with 8 ways and one of the way is by reflecting and diffusing it. A sound will be reflected when it hits a plane or field and it will be diffused when it comes into contact with pointed plane. Such behavior is proven by the result of ray diagram in the simulation towards the model of Bangsal Srimanganti both in the original and modified version. Following are the examples of simulation results in the original model of Bangsal Srimanganti (the complete model with tumpangsari and column) (Fig. 4) and the modified version those are Bangsal with only tumpangsari (Fig. 5) Bangsal with only column (Fig. 6).

Reflected behavior also lead the phenomenon of buzzing sound that can be measured during buzzing or Reverberation Time (RT). Based on the data, the RT in each model is different with the same frequency. The data were then analyzed using statistical analysis with the assistance of SPSS Software. The details explanation for each model will be as follows.

Complete model: Based on statistical result, it is found that the minimum reverberation time for complete model of Bangsal Srimanganti is 8.38 sec, the maximum RT is 10.83 sec and the average RT is 6.29 sec. This is in accordance with the findings from Suyatno (2013) stating the gamelan music has the range of RT from 0.5 sec up to 10.7 sec.

Modification model: Based on the statistics, it is found the reverberation time in the modification model is as follows.

- Without the column and the Tumpangsari, Bangsal Srimanganti has minimum RT of 3.15 sec, maximum RT of 14 sec and average RT of 6.4 sec
- With only the column, Bangsal Srimanganti has minimum of RT 3.22 sec, maximum RT of 16.12 sec and average RT of 6.92 sec
- With only Tumpangsari, Bangsal Srimanganti has minimum RT of 2.36 sec, maximum RT of 10.31 sec and average RT of 6.02 sec

The differences and variation of RT in this analysis will be further examined to answer the second research question about the important elements of building in Javanese acoustic.

Comparative analysis of acoustic behavior in Bangsal Srimanganti: Based on the statistical result, it is found that there is variation of reverberation time. The variation of RT will be the basis in determining of the most

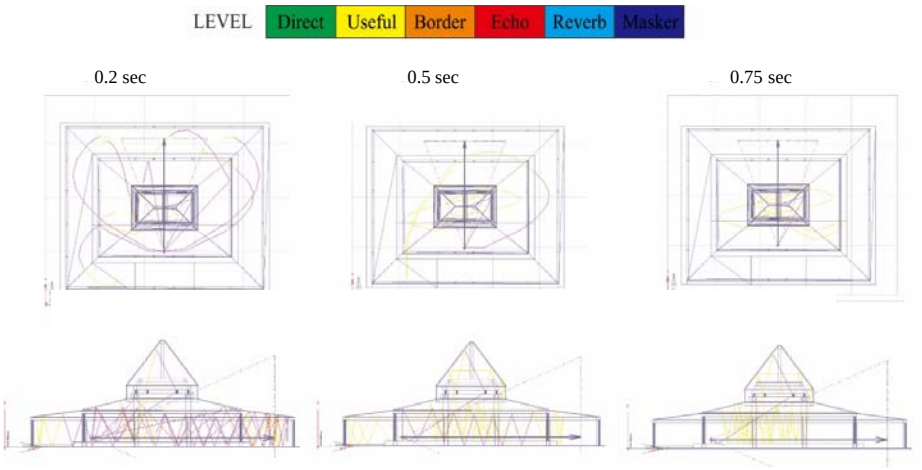

Fig. 4: Ray diagram for the complete model of Bangsal Srimanganti

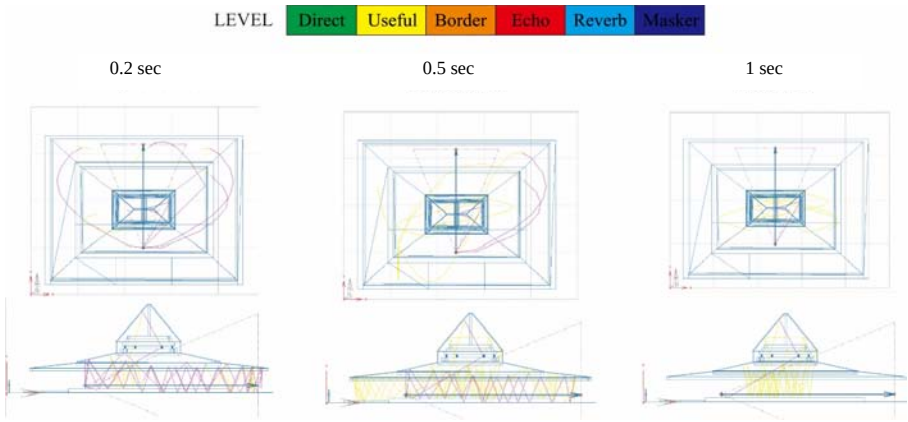

Fig. 5: Ray diagram of modification model with only Tumpangsari of Bangsal Srimanganti

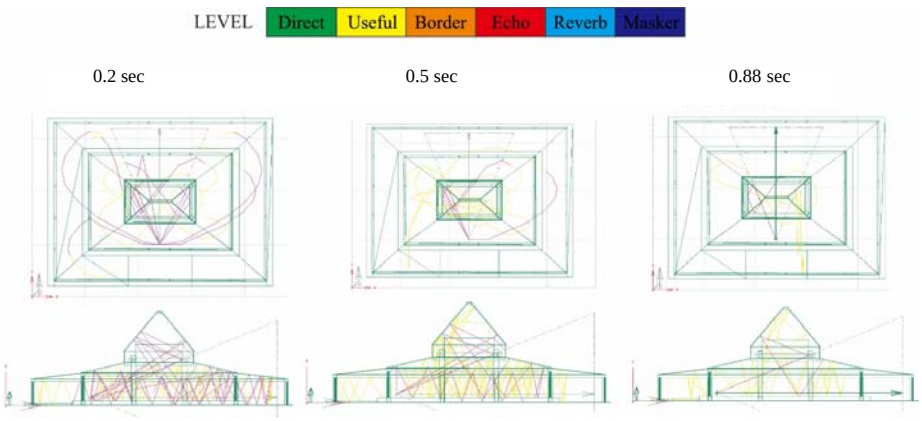

Fig. 6: Ray diagram for modification model with only column of Bangsal Srimanganti

significant Javanese building element in treating Javanese music sound. The data for this were taken from the simulation result.

The data that have been collected where then compared using the help from SPSS application. There are four models and the two models became the control data

variable as follows, original model, only column model, only tumpangsari model without column and Tumpangsari (empty) model.

Control data variable is the reverberation time resulted by the original model of Bangsal Srimanganti and the model without column and Tumpangsari. This research conducted two comparison processes that is significance of original model with the modified model as well as empty model. The result of comparison is as follows:

The comparison of original model and modified model
Original model with column only: From the statistics, it is found that the comparison between the original models with the column only has the correlation value of 0.911 and significance value of 0.001. As mention in the analysis method in the comparison, the original model used the reliability level of 95% with level of error of 5% (0.05) and the best correlation score is 1. Thus, significance value of column is high with the error level of 0.1% (0.001) and correlation value <1 (0.911).

Original model only with tumpangsari: From the statistics, it is found the comparison between the original models with the Tumpangsari only has the correlation value of 1 and significance value of 0.000. This analysis uses the reliability level of 95% with error level of 5% (0.05). In addition, the best correlation value is 1. Thus, the significance value of Tumpangsari is really well with the error level of 0% (0.000) and the correlation value of 1.

Comparison between empty model and modified model
Empty model only with column: From the statistics, it is found that the comparison of blank value with one column model has the correlation value of 0.999 and the significance value of 0.000. With the reliability level of 95% and error level of 5% (0. 05) the best correlation value is 1. Although, the significance value of the column is really well with the error level of 0% (0.000), the value of correlation is still under 1 (0.99).

Original model only with tumpangsari: The statistics indicated that the comparison of empty model with Tumpangsari model has the correlation value of 0.922 and significance value of 0.000. This is the same with previous research with the reliability level of 95% and error level of 5% (0,05). In addition, the best correlation value if 1. Thus, the significance value of Tumpangsari is good but the correlation value is <1 (0.922).

Based on the difference examination between the model with Tumpangsari and the complete model and the empty model with only column model with complete model or empty model it can be seen that the Tumpangsari and column has the same value of significance. Tumpangsari and column are unique component that specially become the signature of Javanese traditional architecture. In this research, both Tumpangsari and column is proven significantly influence the acoustic behavior from RT.

Tumpangsari is a very special in the field of plafond. The importance of plafond in acoustic of room is line with the research from Eldakdoky (2017). The research aimed to optimize two classroom that lead to the big role of plafond that may cause shadow zone to almost 50% of the audience. The importance of column role in the room acoustic is also in line with the research of Hwang and Choi (2017). Although, the research was not specifically aimed to see the role of column in the room acoustic but in the conclusion it stated that the impact from the room acoustic is one of them caused the structural column.

This becomes the indication that the study of traditional architecture (Javanese) has another dimension of studies that can be developed outside the historical, symbolical meaning and so on. The studies of technological function become the opportunity to architectural knowledge which in this case is building science and technology especially the acoustic. This finding is aligned with the finding from Jablonskaa *et al.* (2015). They found continuous evidence about positive mutualism symbiosis since the era of Antiquity and from ancient Greece and Rome era up to "vineyard" configuration of Berlin Philharmonic Hall. The equality of traditional architecture study should be developed.

Based on the discussion above, it can stated that although the column and Tumpangsari has a big and significant difference with the compared model but both elements have different value in strength of correlation. Tumpangsari has higher correlation value compared to the column. Thus, Tumpangsari is a very important element to be optimized in the application of traditional architecture especially joglo Mangkurat in its modern function.

CONCLUSION

Based on the observation in the simulation of the four models, it has been proven that Javanese traditional building treated the sound of Javanese music by reflecting and diffusing it. The behavior of reflecting and diffusing lead to the phenomenon of Reverberation Time (RT) that can be observed in the RT. The RT obtained from the four models varies. The variation is used as the material in determining the building elements with the most significant influence in treating sound in the Javanese traditional building.

Based on the findings, it is indicated that Tumpangsari and column influence significantly in

treating gamelan music acoustic. However, for the need of the newest application because Tumpangsari has higher value of correlation than the column therefore, the Tumpasari will be the strategic element to be optimized in the revitalization of traditional building of Joglo, especially for the musical function.

The conclusion and discussion above and the series of discussion that follows bring to one final conclusion about the importance of rethinking traditional architecture by developing the research and intensive studies in the review of building science technology, so that, the local wisdom and local traditional architecture can be revitalized in the recent application.

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