COMPARATIVE ANALYSIS OF THE STRUCTURAL STRENGTH OF UII BOY'S DORMITORY AND GIRL'S DORMITORY BUILDINGS AGAINST EARTHQUAKES

Putra Rafif Nugroho, Johanita Anggia Rini, Hilmi Nur Fauzi
Department of Architecture, Universitas Islam Indonesia
Email: 20512170@students.uii.ac.id

Abstract: *Dwelling is a primary need for every individual in carrying out their daily lives. Dwelling eventually evolved into several types, adapting to conditions and environmental factors that occur in a particular area. In several cities in Indonesia, especially Yogyakarta, also called "Kota Pelajar", many immigrants want to continue their academic studies. This supports the existence of several parties who decide to provide temporary housing which is commonly called boarding houses, rented houses, and dormitories which are often provided by academic institutions. This requires that the building has good structural strength in handling earthquake disasters because Indonesia has a geographical position that is prone to these disasters. This makes me, as a writer, interested in finding out and comparing the structural strength of the UII boy's dormitory and girl's dormitory to find out which building has better structural strength in dealing with earthquake disasters. As for further conclusion, both buildings are not efficient enough in resisting earthquakes so it is still possible for both minor and major damage to be experienced by the two buildings.*

Keywords: Comparison, Earthquake, Structural Strength, UII Dormitory.

INTRODUCTION

Background

Over time, housing has undergone changes as well as adjustments and evolved into various types, both in terms of function and form. This change is due to an adjustment of environmental conditions and factors that are occurring in an area. This causes a dwelling to make each user have a sense of desire whether to stay temporarily or continuously. Based on these several factors, a group will later choose a dwelling not only from the comfort aspect of the building itself but also the environment of the place

A dormitory is a housing facility that is usually provided by educational institutions or companies to provide temporary housing for students, employees, or participants in training programs. Dormitories often consist of several buildings or blocks containing bedrooms, common rooms, shared kitchens, and other common facilities. According to Soekanto (2012), a dormitory is "a temporary residence reserved for certain individuals or groups, such as students, which functions as a place to live, study, and interact with fellow dormitory residents."

According to research conducted by Sari and Wijayanto (2018), dormitories have a positive impact on student personal development. Students living in dormitories have the opportunity to study independently, manage time, develop social skills, and improve adaptability. In addition, the hostel also provides supporting facilities such as study rooms, internet access, and meeting rooms. This facility allows students to focus on their studies and improve academic performance.

Yogyakarta, which is also usually called "Student City", has many immigrants who want to continue their academic studies. This supports the existence of several parties who decide to provide temporary housing which is commonly called boarding houses, rented houses, and dormitories which are often provided by academic institutions. This also encourages UII to provide dormitories as one of the facilities that can be used by students who come from outside the city of Yogyakarta. UII provides two separate dormitory buildings intended for students and female students.

Yogyakarta is one of the cities located in the country of Indonesia which is also usually called “Kota Pelajar”. Indonesia is famous for its geographical location which makes this country prone to earthquakes. This is because Indonesia is geographically located in the Pacific Ring of Fire. the confluence of three world tectonic plates, the Indo-Australian Plate, the Eurasian Plate, and the Pacific Plate.

Based on the explanation above, it can be seen that a building that stands and is built in Indonesia is required to be able to deal with earthquake disasters. A strong structure and planned development must be prepared and considered from the start of the building design. This applies to every type of building, including the function of the building itself. especially the UII dormitory which is used as a temporary residence for UII students.

Problem Formulation

1. What are the characteristics of earthquake-resistant buildings?
2. Between the building structures of the UII boy’s Dormitory and the Girl's dormitory buildings, which one is more ideal for dealing with earthquakes?

Research Purpose

1. Find out the characteristics of an earthquake-resistant building.
2. Comparison to find out which tower is more resistant to earthquakes at the UII dormitory buildings.

Theoretical Review

Earthquake-resistant buildings are buildings specifically designed to be able to withstand vibrations and forces caused by earthquakes. Various factors that must be considered in designing earthquake-resistant buildings include the nature and characteristics of the soil at the building site, the type and quality of building materials, and the design of the building structure.

According to Zhang et al. (2020), there are several strategies that can be applied in designing earthquake-resistant buildings, including:

1. The use of materials that have high strength and good flexibility, such as reinforced concrete, steel, and laminated wood.
2. Increase the adhesion between the structural elements of the building, for example by using bolts and fasteners.
3. Reducing building mass by designing more efficient building structures and using lighter materials.
4. Improve the vibration-damping system of buildings by using earthquake-damping systems such as shear isolators and shock absorbers.
5. Designing structural systems that are flexible and adaptable to soil deformations that occur during earthquakes.

Another article, written by Saeed et al. (2020), explained that apart from the factors above, the geometric design of the building also plays an important role in increasing the resistance of buildings to earthquakes. Good geometric design can minimize the effect of earthquake forces on the building structure.

In practice, designing earthquake-resistant buildings requires careful calculations and the use of the latest technology. However, by taking into account the factors described above, it is expected to minimize the risk of damage and destruction to buildings due to earthquakes.

According to Herianto (2020), Earthquake resistant buildings have several main characteristics that can be distinguished from conventional buildings. Following are some of the characteristics of earthquake-resistant buildings:

1. Strong structural design: Earthquake-resistant buildings must be designed with strong structures that can withstand the shocks that occur during an earthquake. The structure usually uses a steel frame or reinforced concrete.
2. Use of strong materials: In addition to strong structural designs, earthquake-resistant buildings also use strong materials such as high-quality concrete and high-quality steel. The use of strong materials can increase the resistance of buildings to earthquakes.
3. Earthquake-resistant systems: Earthquake-resistant buildings are also equipped with earthquake-resistant systems such as earthquake absorbers, shear barriers, or isolator systems. This earthquake-resistant system serves to withstand and dampen the vibrations that occur during an earthquake.
4. Flexible architectural design: Earthquake-resistant buildings must be designed with flexible architecture so that they can withstand and absorb the shocks that occur during an earthquake. Flexible architectural designs can reduce the risk of damage to buildings during an earthquake.
5. Strong construction: Earthquake-resistant buildings must be built with strong and proper construction. Improper construction can increase the risk of damage to buildings during an earthquake.

According to Andrew Charleson, an expert in the field of earthquake-resistant building planning, there are several characteristics that must be possessed by these buildings. According to Charleson (2010), the main characteristics of earthquake-resistant buildings include a strong and flexible structural system, the use of shock-resistant materials, and planning that takes into account the strength and interaction between building elements.

First, a solid and flexible structural system is one of the important characteristics of an earthquake-resistant building. The building must be designed with a frame system that is able to absorb seismic energy properly and distribute it evenly throughout the structure. This can be achieved by using the right materials and construction technology, such as steel which has high strength and bending ability.

Second, the selection of materials that are resistant to shocks is also an important factor. The material used must have the ability to withstand the deformation and shock forces generated by earthquakes. For example, reinforced concrete reinforced with steel can give a building additional strength.

In addition, planning that considers the strength and interaction between building elements is also required in earthquake-resistant buildings. The structure must be designed taking into account factors such as rigidity, strength and stability in order to be able to resist earthquake forces effectively. In addition, building elements must also interact well with each other to avoid potential collapse due to shocks.

In order to achieve the characteristics of earthquake-resistant buildings mentioned above, a holistic and multidisciplinary approach is needed in building planning and design. This involves collaboration between architects, structural engineers and seismologists in integrating earthquake safety principles into the entire building process. In this way, buildings can become more resilient to earthquakes and protect the lives and property of their occupants.

In the search for the strength of buildings that are resistant to earthquakes, there is one way to check the structural strength of a building. namely by using Rapid Visual Screening (RVS) which will be followed by testing using the Resist application. In using RVS, it is necessary to check the seismic risk level for the project site.

Risk level class according to BNPB (Perka BNPB No. 2 of 2012), there are 3 classes; Low, Moderate, and High.

Risk Level Class		
Low	Moderate	High
PGA < 0,2501	PGA 0,2501 - 0,70	PGA > 0,70

METHOD

In this research, I as the author used a qualitative method approach with a primary data collection system that was carried out by visiting the building directly and collecting the technical drawing of each building.

RESULT AND DISCUSSION

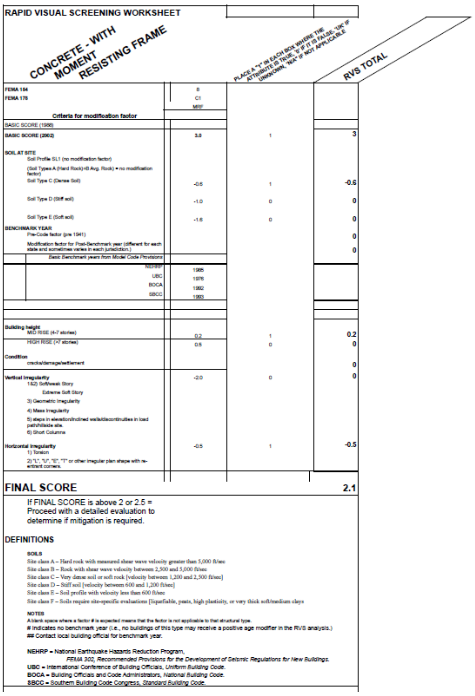
First, by checking the seismic risk level of the two buildings that were being studied, the data shows that both the boy's and girls' dormitories are included in the moderate risk level. with the PGA value of the men's building 0.4355 while the PGA of the women's building is 0.4137.

1. Boy’s dormitory PGA Result
Source: Private Document

2. Girl’s dormitory PGA result
Source: Private Document

By using this data, the researcher proceeded to enter the data that were had into the assessment using RVS or Rapid Screening Visual. In the use of structural strength testing using the RVS method, if the results show a number above 2, it indicates that the building is good enough to withstand earthquakes.

by testing using RVS, the results show that the male dormitory building has a value of 2.1. Meanwhile, for the female dormitory, it has a value of 2.6.



RAPID VISUAL SCREENING WORKSHEET

CONCRETE - WITH MOMENT RESISTING FRAME

Criteria for modification factor		PLACE A "1" IN EACH BOX WHERE THE ATTRIBUTE IS TRUE, "0" IF IT IS FALSE, "UK" IF UNKNOWN, "N/A" IF NOT APPLICABLE	RVS TOTAL
FEMA 154	8		
FEMA 178	C1 MRF		
BASIC SCORE (1988)			
BASIC SCORE (2002)	3.0	1	3
SOIL AT SITE			
Soil Profile SL1 (no modification factor)			
(Soil Types A (Hard Rock)+B Avg. Rock) = no modification factor)			
Soil Type C (Dense Soil)	-0.6	1	-0.6
Soil Type D (Stiff soil)	-1.0	0	0
Soil Type E (Soft soil)	-1.6	0	0
BENCHMARK YEAR			
Pre-Code factor (pre 1941)			0
Modification factor for Post-Benchmark year (different for each state and sometimes varies in each jurisdiction.)			0
Basic Benchmark years from Model Code Provisions			
NEHRP	1985		
UBC	1976		
BOCA	1992		
SBCC	1993		
Building height			
MID RISE (4-7 stories)	0.2	1	0.2
HIGH RISE (>7 stories)	0.5	0	0
Condition			
cracks/damage/settlement			0
Vertical Irregularity	-2.0	0	0
1&2) Soft/weak Story			
Extreme Soft Story			
3) Geometric Irregularity			
4) Mass Irregularity			
5) steps in elevation/inclined walls/discontinuities in load path/hillside site.			
6) Short Columns			
Horizontal Irregularity	-0.5	1	-0.5
1) Torsion			
2) "L", "U", "E", "T" or other irregular plan shape with re-entrant corners.			
FINAL SCORE			2.1

If FINAL SCORE is above 2 or 2.5 = Proceed with a detailed evaluation to determine if mitigation is required.

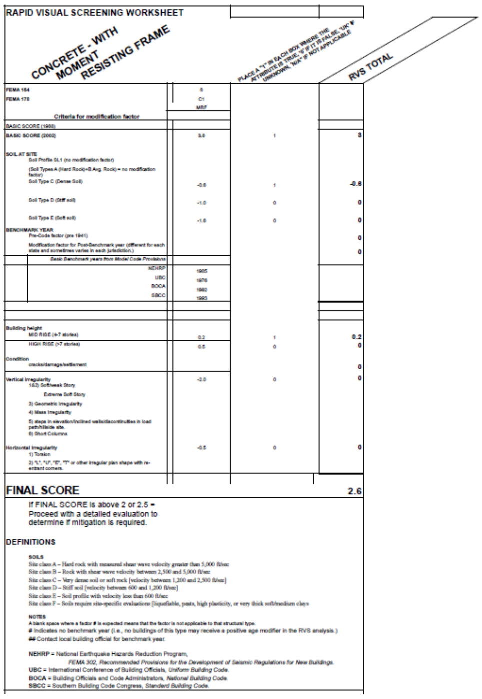
DEFINITIONS

SOILS
Site class A – Hard rock with measured shear wave velocity greater than 5,000 ft/sec
Site class B – Rock with shear wave velocity between 2,500 and 5,000 ft/sec
Site class C – Very dense soil or soft rock [velocity between 1,200 and 2,500 ft/sec]
Site class D – Stiff soil [velocity between 600 and 1,200 ft/sec]
Site class E – Soil profile with velocity less than 600 ft/sec
Site class F – Soils require site-specific evaluations [liquefiable, peats, high plasticity, or very thick soft/medium clays

NOTES
A blank space where a factor # is expected means that the factor is not applicable to that structural type.
# Indicates no benchmark year (i.e., no buildings of this type may receive a positive age modifier in the RVS analysis.)
Contact local building official for benchmark year.

NEHRP = National Earthquake Hazards Reduction Program, *FEMA 302, Recommended Provisions for the Development of Seismic Regulations for New Buildings.*
UBC = International Conference of Building Officials, *Uniform Building Code.*
BOCA = Building Officials and Code Administrators, *National Building Code.*
SBCC = Southern Building Code Congress, *Standard Building Code.*

3. Boy's dormitory RVS Result



RAPID VISUAL SCREENING WORKSHEET

CONCRETE - WITH MOMENT RESISTING FRAME

Criteria for modification factor		PLACE A "1" IN EACH BOX WHERE THE ATTRIBUTE IS TRUE, "0" IF IT IS FALSE, "UK" IF UNKNOWN, "N/A" IF NOT APPLICABLE	RVS TOTAL
FEMA 154	8		
FEMA 178	C1 MRF		
BASIC SCORE (1988)			
BASIC SCORE (2002)	3.0	1	3
SOIL AT SITE			
Soil Profile SL1 (no modification factor)			
(Soil Types A (Hard Rock)+B Avg. Rock) = no modification factor)			
Soil Type C (Dense Soil)	-0.6	1	-0.6
Soil Type D (Stiff soil)	-1.0	0	0
Soil Type E (Soft soil)	-1.6	0	0
BENCHMARK YEAR			
Pre-Code factor (pre 1941)			0
Modification factor for Post-Benchmark year (different for each state and sometimes varies in each jurisdiction.)			0
Basic Benchmark years from Model Code Provisions			
NEHRP	1985		
UBC	1976		
BOCA	1992		
SBCC	1993		
Building height			
MID RISE (4-7 stories)	0.2	1	0.2
HIGH RISE (>7 stories)	0.5	0	0
Condition			
cracks/damage/settlement			0
Vertical Irregularity	-2.0	0	0
1&2) Soft/weak Story			
Extreme Soft Story			
3) Geometric Irregularity			
4) Mass Irregularity			
5) steps in elevation/inclined walls/discontinuities in load path/hillside site.			
6) Short Columns			
Horizontal Irregularity	-0.5	0	0
1) Torsion			
2) "L", "U", "E", "T" or other irregular plan shape with re-entrant corners.			
FINAL SCORE			2.6

If FINAL SCORE is above 2 or 2.5 = Proceed with a detailed evaluation to determine if mitigation is required.

DEFINITIONS

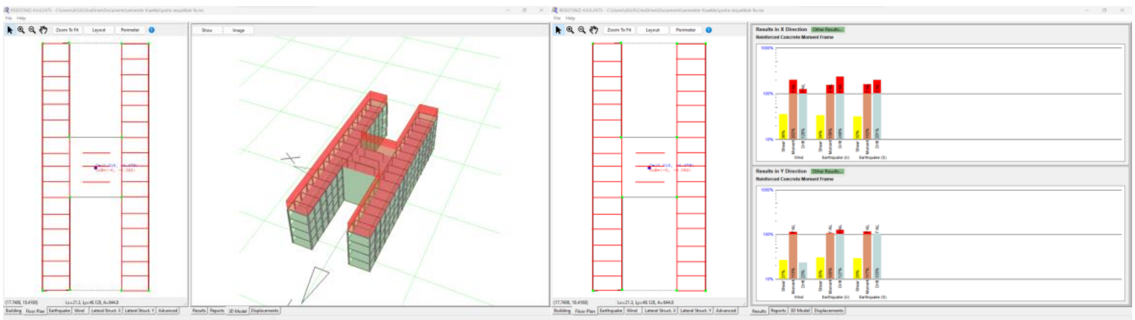
SOILS
Site class A – Hard rock with measured shear wave velocity greater than 5,000 ft/sec
Site class B – Rock with shear wave velocity between 2,500 and 5,000 ft/sec
Site class C – Very dense soil or soft rock [velocity between 1,200 and 2,500 ft/sec]
Site class D – Stiff soil [velocity between 600 and 1,200 ft/sec]
Site class E – Soil profile with velocity less than 600 ft/sec
Site class F – Soils require site-specific evaluations [liquefiable, peats, high plasticity, or very thick soft/medium clays

NOTES
A blank space where a factor # is expected means that the factor is not applicable to that structural type.
# Indicates no benchmark year (i.e., no buildings of this type may receive a positive age modifier in the RVS analysis.)
Contact local building official for benchmark year.

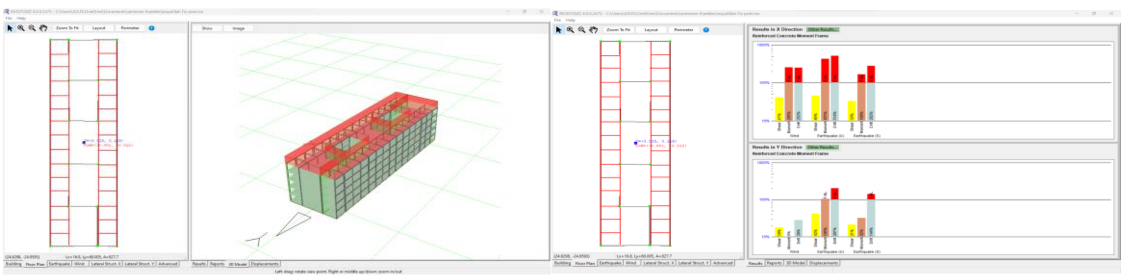
NEHRP = National Earthquake Hazards Reduction Program, *FEMA 302, Recommended Provisions for the Development of Seismic Regulations for New Buildings.*
UBC = International Conference of Building Officials, *Uniform Building Code.*
BOCA = Building Officials and Code Administrators, *National Building Code.*
SBCC = Southern Building Code Congress, *Standard Building Code.*

4. Girl's dormitory RVS Result

Even though both of these buildings show values that indicate that the two buildings can withstand earthquakes well, further research is needed by testing both buildings using the Resist application. In testing using the resist application, data was obtained that the male dormitory buildings had stronger structural strength in the face of earthquakes compared to the female dormitory buildings. This can be seen through the data attached below.



5. Boy's Dormitory Resist result
Source: Private Document



6. Girl's Dormitory Resist result
Source: Private Document

After conducting a simulation test using the resist application, there are results showing that the two buildings are not efficient enough in resisting earthquakes so there is still a possibility for these buildings to experience both minor and major damage. If we compare the two buildings, based on existing data it shows that the Boys' Dormitory has slightly superior structural strength compared to the Girls' Dormitory. This is shown by the bar chart on the resist application which shows a higher failure rate of resisting earthquakes in the female dormitory building.

CONCLUSION

Based on the literature review and carrying out structural strength tests through simulations using the Resist application, the author concludes that the two buildings are not efficient enough in resisting earthquakes so it is still possible for both minor and major damage to be experienced by the two buildings. However, this is a conclusion drawn from limited data and simulations. a simulation and further studies should be carried out in order to obtain more concrete results on the structural strength of the two buildings

REFERENCES

Charleson, A. (2010). Building for Earthquakes: Structural Design Concepts. New York: Taylor & Francis.

Herianto, Topan. (2020). Bangunan Tahan Gempa: Pengenalan Konsep dan Prinsip-Prinsip Dasar. Jurnal Sosial Humaniora, 13(1), 65-73.

Saeed, S., Shafiq, N., Javaid, S., & Khan, M. A. (2020). Review of Seismic Resistance of Geometrically Irregular Buildings. Geosciences, 10(6), 220.

Sari, R. M., & Wijayanto, T. (2018). Pengaruh Asrama Terhadap Perkembangan Pribadi Mahasiswa. Jurnal Pendidikan Insan Mandiri, 3(2), 146-156.

Soekanto, S. (2012). Sosiologi Suatu Pengantar. Jakarta: PT RajaGrafindo Persada.

Zhang, Y., Li, G., Yu, J., & Ou, J. (2020). Overview of earthquake-resistant design and construction technologies of reinforced concrete structures. Advances in Civil Engineering, 2020.