Rapid Assessment of Earthquake Threat Vulnerability in Campus 3 of University of Technology Yogyakarta Based on Android Application

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Abstract

The province of D.I.Yogyakarta is crossed by the Indo-Australian Plate which is one of the three world plates. The impact that occurs when an earthquake happens is the damage to buildings not only simple buildings but also multi-story buildings, such as School Buildings and Educational Facilities. The Campus 3 of University of Technology Yogyakarta is located at Jl. Prof. Dr. Soepomo, S.H. No.21, Muja Muju, the sub district of Umbul Harjo, Yogyakarta. The purpose of this study is to determine the results of the evaluation using the RVS method on a form that is filled out manually and by an application using ArGis. The method used in this research is FEMA 154-2015 which is adjusted to the regulations in Indonesia, namely SNI 1726-2019, and the results are analyzed quantitatively. Based on the checking of vulnerability of the campus building with the RVS High Seismicity form, the campus 3 building is of the type of reinforced concrete frame and functioning as a school. The results obtained show that the average of two buildings in the Campus 3 of University of Technology Yogyakarta is 2.3, and the RVS stops at level 1. Both conditions confirm that the two buildings have a risk that is not dangerous. Nevertheless, there should be a further supervision.

Keywords: Android, App, Building, Campus, Vulnerability.

I. INTRODUCTION

Indonesia is one of the countries that are prone to earthquakes. This is due to its geographical location of Indonesia which is at the confluence of the three largest tectonic plates in the world, namely the Indo-Australian Plate, the Eurasian Plate, and the Pacific Plate[1]. Earthquakes are caused by a sudden shift of the earth's plates beneath the earth's surface[2]. The shift occurs due to the emergence of vibrations called seismic waves. This wave propagates away from the epicenter in all directions. When the wave propagates to the ground surface, the vibration can be destructive or not, depending on how big the source strength and distance is, as well as the influence of other things such as the quality of the soil and the structure of the building[3].

Given the high risk of earthquakes, it is appropriate that all high-rise buildings in Indonesia must be designed and planned following the references from the government[4], namely the Indonesian National Standard regarding Earthquake Resistance[5]. However in reality, not all buildings are planned and carried out properly and appropriately and have followed the applicable regulations[6], This negligence can lead to unwanted events during an earthquake, for example, an earthquake that occurs will trigger shaking in the building, if the building is not designed properly to be able to withstand earthquake loads that occur other than the factored ultimate load, the structural elements of the building will lose. causing the building to collapse[7]. Another example is the concrete blanket[8]which covers the core reinforcement in each structural element, especially the column[8]that withstands axial loads will break due to the sudden swaying of the building. It will cause a moment that results in the emergence of stresses beyond the ability of the structural elements so that the building will collapse[9].

Yogyakarta is also one of the densely populated areas in Indonesia [10][11]. The construction of buildings in Yogyakarta increases, including in the field of education, one of which is the campus building[12]. This type of building has potential or has a big impact if it is done without careful planning, one of which is because the building is categorized as an important facility [13].

Campus 3 of University of Technology Yogyakarta is located on Jl. Prof. DR. SoepomoSh No.21, Muja Muju, Kec. Umbulharjo, Yogyakarta City, D.I. Yogyakarta. The campus has 2 buildings with a height of 2 to 3 floors. This building is an old building, and it is classified as a critical facility. Nonetheless, it has a high risk in earthquake-prone areas. To take preventive measures to overcome any matters, it is necessary to include strengthening the building structures, using materials with references, and carrying out building feasibility checks every 5 years or periodically by applicable regulations. One way to solve this problem is to use the Rapid Visual Screening (RVS) method.

Rapid Visual Screening (RVS) is a method of assessing the condition of buildings against potential earthquake hazards by visually examining the exterior of the building, and interior if possible so that the implementation is relatively fast[14]. This Rapid Visual Screening has been carried out in various countries[14] because the RVS method is easy to apply and without performing structural calculations[15]. Implementation of the assessment or evaluation of the RVS method by filling out a form derived from the FEMA 154 handbook, the contents of the RVS form such as soil type, building use, address, number of floors, building age, and others. The final stage of filling out this form is the sum of the scores from the data obtained for each evaluated building. If the score obtained is more than or equal to 2 then the building is declared not vulnerable, and vice versa if it is less than 2 then the building is considered vulnerable and it is recommended to be checked again using the FEMA 310 Handbook for the Seismic Evaluation of Building reference[16]. After conducting the Rapid Visual Screening, this effort can be accelerated by planning in the field, including screening training, and careful management of the entire process as a whole[17]. Data collection in the field begins with identifying the seismic strength of the main structure and structural material of the building[18].

The screener performs a rapid seismic assessment of the building's RVS form to assess buildings in areas with or without occupancy risk before or after an earthquake. These series of procedures are usually carried out manually by filling out an on-site damage assessment form, even though the increasingly advanced technology can make it easier for us to filter buildings. In the Industry 4.0 era, Indonesia's information and communication technology continue to develop and advance with the times, allowing everything to be done quickly and efficiently. Smartphone technology which was previously only used for communication between individuals can now be a source of information to access the internet via smartphones.

The development of smartphone technology has become very important after the existence of the Android operating system. Most of the devices on the market today use this operating system. The software supports much geographic information work that previously used cartography, including the application of geographic information systems to assess earthquake damage to soil and construction. The manual method is considered inefficient because of the relatively long data collection time and the long typing or data entry process into the form because the filter fills out the form manually.

ArcGIS Survey123 is a simple but powerful form of data collection application that enables the creation, sharing, and analysis of surveys. The ArcGIS Survey123 smartphone application can be used for data collection by anyone, it can be downloaded from the Playstore from our smartphones. The ArcGIS Survey123 application is very easy to use. We can use it with or without training, and both in online and offline environments.

Although the structure of the campus building has not been calculated, the software will be used to perform a visual assessment of the research. The purpose of this study was to determine the results of the assessment of the vulnerability of campus buildings to earthquakes using the RVS form filled out manually or digitally.

II. METHOD

A. Location and Time Of Research

A research location is a place or area where the research will be carried out. This research location is on Campus 3 of University of Technology Yogyakarta, located on Jl. Prof. DR. Soepomo SH No.21, Muja Muju, Kec. Umbulharjo, D.I. Yogyakarta. The time in this study was carried out from February to March 2022.

Figure 1. Map of the location of the campus building 3

B. Collect Data

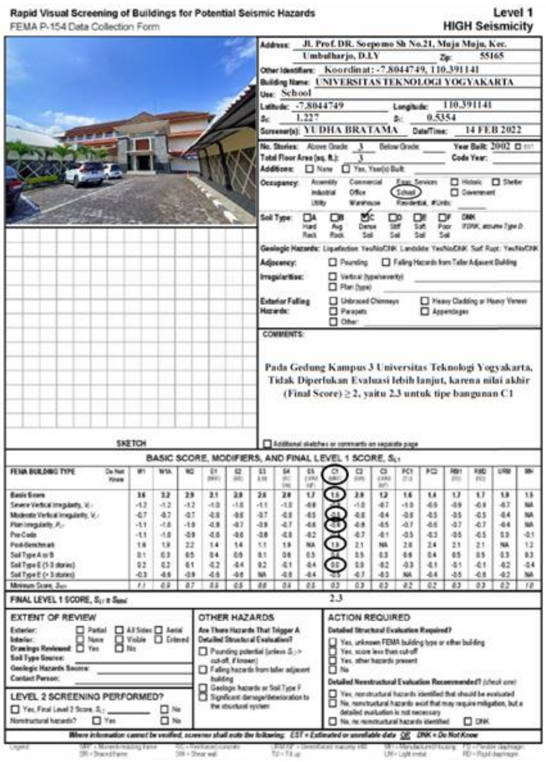
Sensitivity Analysis on Campus 3 Building which is located on Jl. Prof. DR. SoepomoSh No.21, Muja Muju, Kec. Umbulharjo, D.I.Yogyakarta against earthquakes based on the method on FEMA 154, namely Rapid Visual Screening (RVS). To start this research, it is necessary to look for the guidelines and references such as: *Rapid Visual Screening of Buildings for Potential Seismic Hazards: A Handbook, Third Edition* (FEMA P-154, 2015), *Rapid Visual Screening of Buildings for Potential Seismic Hazards: Supporting Documentation, Third Edition* (FEMA P-155, 2015), "*Tata Cara Perencanaan Ketahanan Gempa untuk Struktur Bangunan Gedung dan Non-gedung* (Earthquake Resistance Planning Procedures for Building and Non-building Structures)" (SNI

1726:2019), *"Peta Sumber dan Bahaya Gempa Indonesia tahun 2017* (Map of Sources and Hazards of the 2017 Indonesian Earthquake)", dan *"Persyaratan beton struktural untuk bangunan gedung dan penjelasan* (Structural Concrete Requirements For Building Buildings And Explanations)" (SNI 2847:2019). The next thing to do is collecting data from the internet, interviews, and field surveys, then to fill out the RVS form according to the data obtained. After determining the RVS form based on each earthquake area, the next stages of implementation according to the guidelines are as follows:

1. Learn FEMA P-154 Building Identification Information.
2. Understand Building Characteristics of FEMA P-154.
3. Photograph the building and attach photos.
4. Walk around the building to identify its size and shape and sketch the building on the form.
5. Define and document occupancy.
6. Determine the type of soil.
7. Learn Geological Hazards.
8. Identify the Proximity (adjacency).
9. Identify Irregularities or Deviations.
10. Find The danger of Falling Exterior Components.
11. Fulfill the comments section.
12. Identify seismic lateral-load resisting and circle the base score on the form.
13. Identify and circle according to the condition of the building on each modification score.
14. Document the Inspection Level.
15. Document Level 2 Examination Results.
16. Document Other Hazards.
17. Determine the Action Required.

Or with the example of the steps for filling out the RVS form in Figure 2 and Figure 3, including:

a) Verify information about the object of the building under study.
b) Survey the field to find out the number of floors, whether the shape of the building is symmetrical or not, and whether it has a different level of height for each floor, and draw the points of columns and beams, to make observations on the roof floor.
c) Take photos of the building under study, the environment, and the floor plan of the building.
d) Determine the type of soil and knowing the historical, geological, and geographical risks.
e) Identify the rehabilitation, the reconstruction, the restructuring of potential irregularities in buildings, and the potential hazards of interior and exterior items.
f) Obtain the minimum building value by determining the type of building, the materials, the construction, the earthquake-resistant systems, and the building plans.
g) Determine the value of the first level by adding all the existing values including the deviation to get the last value (S).
h) Calculate the scoring results on the first Tier, if it doesn't meet then it goes into the second Tier scoring, and if it doesn't meet then it will enter the third Tier[19].



Rapid Visual Screening of Buildings for Potential Seismic Hazards
FEMA P-154 Data Collection Form

Level 1
HIGH Seismicity

Address: Jl. Prof. DR. Soepomo Sh No.21, Muja Muju, Kec. Umbulharjo, D.I.Y Zip: 55165
Other Identifiers: Koordinat: -7.8044749, 110.391141
Building Name: UNIVERSITAS TEKNOLOGI YOGYAKARTA
Use: School
Latitude: -7.8044749 Longitude: 110.391141
S_S: 1.227 S_1: 0.5354
Screener(s): YUDHA BRATAMA Date/Time: 14 FEB 2022
No. Stories: Above Grade 3 Below Grade Year Built: 2002
Total Floor Area (sq. ft.): 3 Code Year:

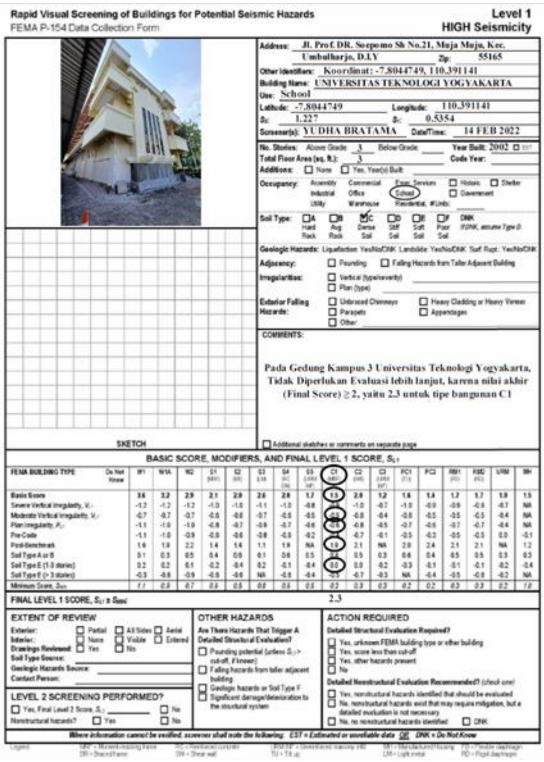
COMMENTS:
Pada Gedung Kampus 3 Universitas Teknologi Yogyakarta, Tidak Diperlukan Evaluasi lebih lanjut, karena nilai akhir (Final Score) ≥ 2, yaitu 2.3 untuk tipe bangunan C1

SKETCH

BASIC SCORE, MODIFIERS, AND FINAL LEVEL 1 SCORE, S_{L1}

FINAL LEVEL 1 SCORE, $S_{L1} \geq S_{MIN}$: 2.3

Figure 2. Tier 1 Form Section 1



Rapid Visual Screening of Buildings for Potential Seismic Hazards
FEMA P-154 Data Collection Form

Level 1
HIGH Seismicity

Address: Jl. Prof. DR. Soepomo Sh No.21, Muja Muju, Kec. Umbulharjo, D.I.Y Zip: 55165
Other Identifiers: Koordinat: -7.8044749, 110.391141
Building Name: UNIVERSITAS TEKNOLOGI YOGYAKARTA
Use: School
Latitude: -7.8044749 Longitude: 110.391141
S_S: 1.227 S_1: 0.5354
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SKETCH

BASIC SCORE, MODIFIERS, AND FINAL LEVEL 1 SCORE, S_{L1}

FINAL LEVEL 1 SCORE, $S_{L1} \geq S_{MIN}$: 2.3

Figure 3. Tier 1 Form Section 2

Then it is very important to fill out the RVS form manually and digitally (android application). For the manual method, we use the form in the FEMA P-154 manual, then print and fill it out. Then, for the digital method (android application) we use the ArGis application (Survey 123), and after that we log in with the account that has been set to fill out the RVS form and get the results directly at the end of filling out. Finally, we can conclude from the results obtained.

III. RESULT AND DISCUSSION

A. Ss and S1 assessments are generated based on building coordinates

The results of reading the value of the MCE Spectral Response value for a short period, 5% attenuation (Ss) are seen in Figure 4 and the MCE Spectral Response for a period of 1 second with 5% attenuation (S1) is seen in Figure 5 based on the coordinates of the building location obtained from google maps, the data can be seen in Table 1 which shows the buildings reviewed in this study. While the condition of the building is on SC soil (Soil Hard Rock Soft).

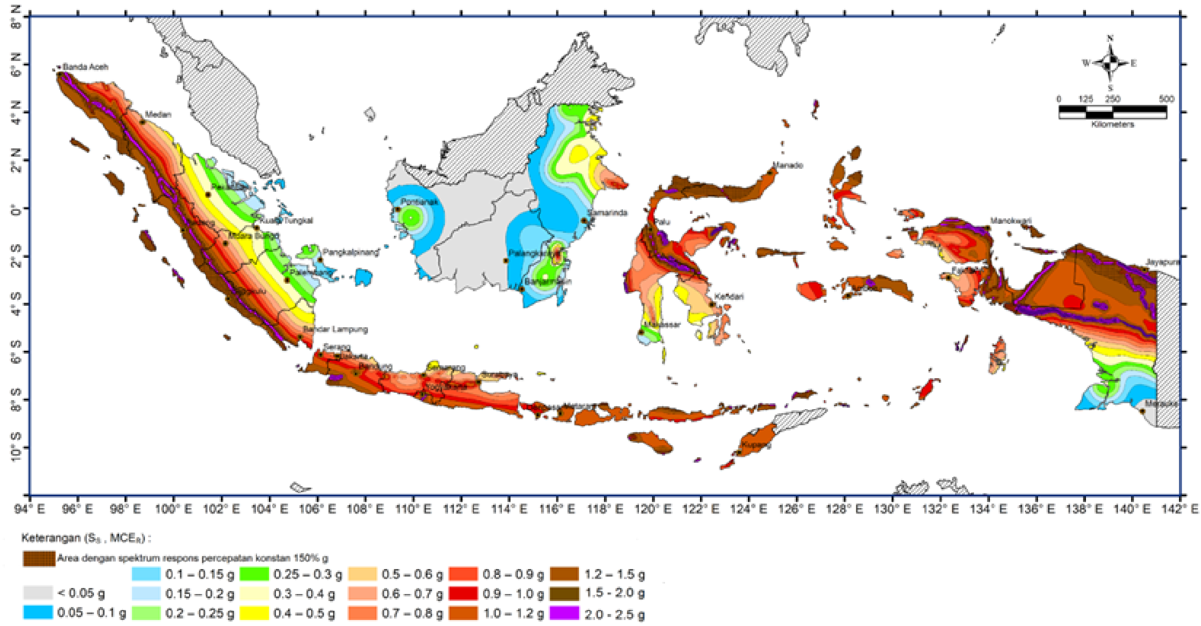

Figure 2. Ground motion parameter Ss (SNI 1726, 2019)

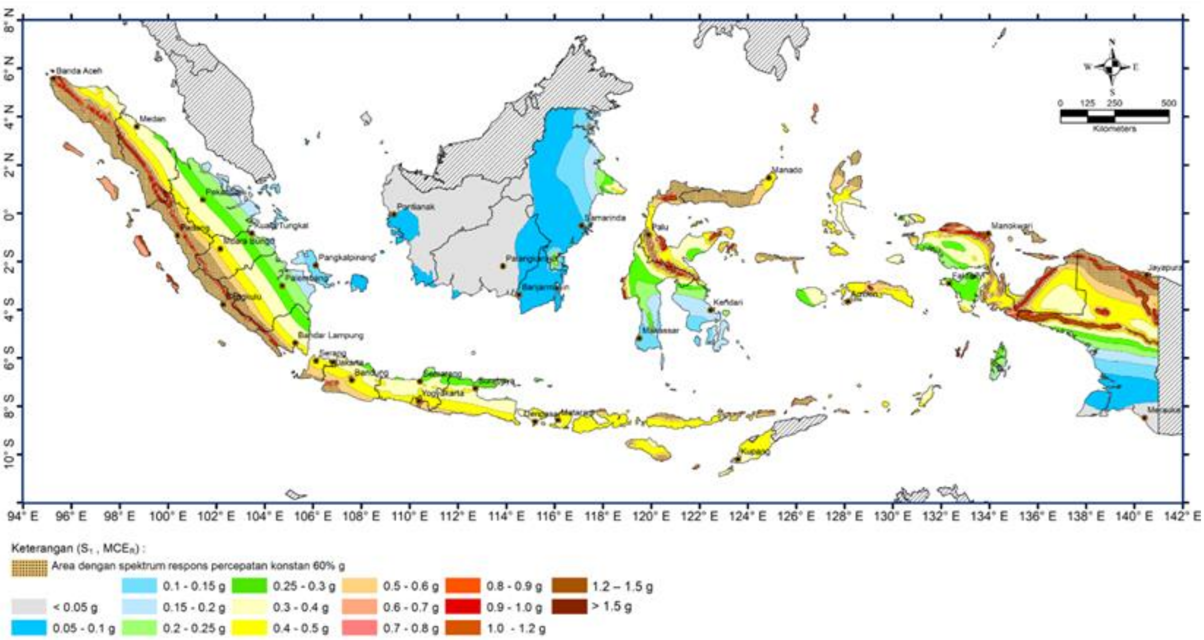

Figure 3. Ground motion parameter S1 (SNI 1726, 2019)

Table 1. Earthquake area based on spectral response acceleration (FEMA P-154, 2015)

Seismicity Region	Spectral Acceleration Response, Ss (short period, or 0.2 seconds)	Spectral Acceleration Response, S_1 (long period, or 1.0 seconds)
Low	< 0.250 g	< 0.100 g
Moderate	0.250 g < Ss < 0.500 g	0.100 g < S_1< 0.200 g
Moderately High	0.500 g < Ss < 1.000 g	0.200 g < S_1< 0.400 g
High	1.000 g < Ss < 1.500 g	0.400 g < S_1< 0.600 g
Very High	> 1.500 g	> 0.600 g

Table 2 Results of Determining the Values of Ss and S1

Object	Latitude	Longitude	Ss	S_1
Gedung 1	-7.80450	110.39108	1.23g	0.54g
Gedung 2	-7.80468	110.39122	1.23g	0.54g

From the results obtained for the Ss and S1 values in Table 2, and seen in Table 1, it is concluded that the RVS form used is HIGH Seismicity.

B. Building Characteristics

Identifying the characteristics of the building is carried out at the time of the field survey or before. The following are the characteristics of the buildings in the two buildings used as research objects.

- *Campus 3 Section 1*

Figure 4. Campus Building 3 Section 1

The public building has 3 floors and has a land area of approximately 6,500 m^2 and a building area of approximately 600 m^2 on one floor with a total building area of 1,800 m^2. Campus 3 building is a building that is used as a learning center that emphasizes smart technology. It can accommodate many people in carrying out learning activities. Hence, this building is categorized as a school building that is following the form contained in FEMA 154-2015. Campus 3 building is estimated to have around 500 people visiting at the same time.

- *Campus 3 Section 2*

Figure 5. Campus Building 3 Section 2

The public building has 3 floors and has a land area of approximately 6,500 m^2 and a building area of approximately 450 m^2 on one floor with a total building area of 1,350 m^2. Campus 3 building is a building that is used as a learning center that emphasizes smart technology. It can accommodate many people in carrying out learning activities. Hence, this building is categorized as a school building that is following the form contained in FEMA 154-2015. Campus 3 building is estimated to have around 500 people visiting at the same time.

C. Type Of Soil

The type of soil found in the 5-story building is regosol soil type. The type of regosol soil is coarse grains of material from the eruption of Mount Merapi. This soil has a coarse soil texture, coarse grain, easy to erosion, grayish color, tends to be loose, and high-water absorption. The types of soil found at the research site are Hard Soil and Soft Rock (SC) soil types. Soil types are obtained from soil testing data at the location, or by selecting the type of soil in the response spectrum according to SNI 1726-2019 which has the highest response spectrum. The following conclusions are made in Table 3 and Figure 8.

Table 3. Building Characteristics

Object	**Occupancy Type**	**Type of soil**	**Number of Occupants**
Building 1	School	SC (Soft Hard Soil)	101-1.000
Building 2	School	SC (Soft Hard Soil)	101-1.000

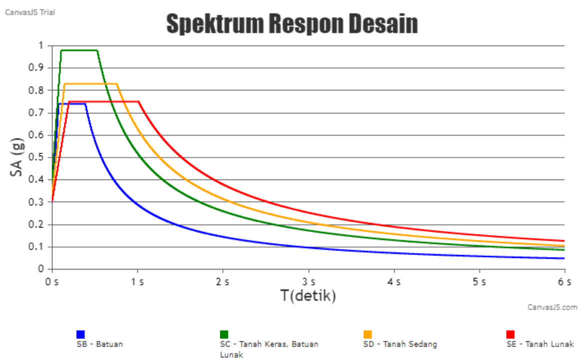

Figure 6. Soil Class

D. Building Assessment

The RVS methodology of buildings can be divided into two categories: (1) buildings that are expected to have acceptable seismic performance, and (2) those that may be seismically hazardous and should be studied further. A value of 2.0 is considered a deduction for standard residential buildings, based on the current scissor design criteria. Using this cut-off level, buildings rated 2.0 or less should be investigated by a design professional with experience in seismic design. A higher value indicates a smaller probability of collapsing. The results of the analysis can be seen in Table 4, the results are classified as vulnerable if an earthquake occurs, this is evidenced by the final score being above the minimum score and not more than a score of 2.

- *Type of building*

The 5-story building is included in the special moment resisting frame according to the FEMA 154 building type.

- *Basic Score*

The basic score that has been listed on the Tier 1 form varies with a basic score that has higher or lower seismicity. The basic score is 1.5. This score is obtained after selecting the building type according to FEMA.

- *Moderate Irregularity*

From the analysis results, the 3-floor building has an irregular vertical which can be in the form of a Split Level. The irregularity shows the difference in height from the lower floor to the upper floor.

- *Plan Irregularity*

The 3-story building is designed with an L shape. In this building, there is a seismic separator on the wing of the building.

- *Post-Benchmark*

This 3-story building was built in 1987 and lasted about two years. In the year of construction using the rules, the reference for the construction of earthquake-resistant buildings with building codes was 1982. In this article, it is adjusted to SNI1726-2019 which means buildings built after the construction rules, after which the Post-Benchmark is chosen.

- *Minimal Score*

This minimum value is the benchmark for the smallest value of the total final score of the Level 1 form. Sometimes the total score produces a negative result. This includes buildings that are 100% vulnerable to earthquakes.

- *Final Score*

The final score is calculated from the total score selected according to the state of the research subject. If a score of 2.0 or less is obtained, it can be said that the building is prone to earthquakes. The results obtained are greater than 2.0, and the more likely the building is invulnerable to the building's vulnerability to earthquakes.

Table 4. Modifier Score

Object	Parameters for Assessment of Rapid Visual Screening (RVS)									
	Building Type	Basic Score	Savere Irregularity	Moderate			Building Type	Basic Score	Savere Irregularity	Moderate
Building No.1	C1	1.5	-	-0.5	-0.6	-	1.9	0.0	0.3	2.3
Building No.2	C1	1.5	-	-0.5	-0.6	-	1.9	0.0	0.3	2.3

IV. CONCLUSION

Based on the results of the earthquake vulnerability evaluation of the campus 3 buildings with the RVS form in manual or digital filling, it can be concluded as follows:

A. The final score on the RVS (HIGH Seismicity) level 1 form of campus 3 building is an average of 2.3 or more than the standard which is 2. Therefore, campus 3 building can be said to have a risk that is not dangerous, although there must be a further supervision.
B. Using an android application makes it easier to work in the field and pre-field, instead of using manual filling.

ACKNOWLEDGMENT,

Infinite thanks to the Directorate of Research and Community Service, Directorate General of Research and Development Strengthening of the Ministry of Research, Technology and Higher Education for financing this research.

REFERENCES

[1] BNPB, "Risiko bencana indonesia," 2016.
[2] I. H. Rifa, H. Pratiwi, and Respatiwulan, "Implementasi algoritma clara untuk data gempa bumi di indonesia," *Semin. Nas. Penelit. Pendidik. Mat.*, no. 2006, pp. 161–166, 2019.
[3] H. Adeswastoto and B. Setiawan, "Evaluasi Kerentanan Bangunan Gedung Utama Universitas Pahlawan Dengan Rapid Visual Screening," *J. Tek. Ind. Terintegrasi*, vol. 6, pp. 274–282, 2020.
[4] D. Kurniati and R. Faizah, "The Quality Assessment of Structure of Simple House in Gowa Sari Residential, Bantul Regency," *Proc. 4th Int. Conf. Sustain. Innov. 2020–Technology, Eng. Agric. (ICoSITEA 2020)*, vol. 199, no. ICoSITEA 2020, pp. 262–266, 2021, DOI: 10.2991/aer.k.210204.047.
[5] Badan Standardisasi Nasional, "Sni 1726-2019," *Tata Cara Perenc. Ketahanan Gempa Untuk Strukt. Bangunan Gedung dan Non Gedung*, no. 8, p. 254, 2019.
[6] "Gempa dan Kualitas Bangunan Publik," *Sindo*, 2018.
[7] H. Prayuda, T. I. Maulana, A. R. Riyandar, and E. P. Siswantoro, "Perancangan Struktur Bangunan 12 Lantai Menggunakan SNI 2847:2013 dan SNI 1726:2012," *J. Apl. Tek. Sipil*, vol. 18, no. 2, pp. 365–374, 2020.
[8] Badan Standardisasi Nasional, "Persyaratan Beton Struktural untuk Bangunan Gedung dan Penjelasan (SNI 2847:2019)," *Badan Stand. Nas.*, no. 8, p. 695, 2019.
[9] J. Glagahsari and N. D. I. Yogyakarta, "Potensi Kerusakan Bangunan Bertingkat Sedang Dengan Skenario Gempa Lebih Besar Sama Dengan 5 Sr," vol. 11, no. 1, pp. 125–139, 2021.
[10] Badan Pusat Statistika, "Kota Yogyakarta Dalam Angka 2021," *BPS Kota Yogyakarta*, pp. 1–446, 2021.
[11] D. Kurniati, "Kajian Analisis Pushover Untuk Performance Based Design Pada Awana Condotel Yogyakarta," *J. Rekayasa Sipil*, vol. 6, no. 1, pp. 85–93, 2019, [Online]. Available: http://riset.unisma.ac.id/index.php/ft/article/view/1879.
[12] M. H. Zulfiar and M. I. I. Zai, "Penilaian Kerentanan Bangunan Terhadap Gempa Bumi pada Gedung Perkuliahan Berlantai Tinggi di Yogyakarta," *Bull. Civ. Eng.*, vol. 1, no. 2, pp. 73–80, 2021, doi: 10.18196/bce.v1i2.11075.
[13] D. WIDYAWARMAN and E. R. Fauzi, "Aplikasi Mikrotremor Untuk Mikrozonasi Tingkat Potensi Bencana Gempa Bumi Di Kampus I Universitas Pgri Yogyakarta," *J. Geosaintek*, vol. 6, no. 2, p. 87, 2020, doi: 10.12962/j25023659.v6i2.6778.
[14] M. E. Committee *et al.*, "Guideline for Rapid Visual Screening of Buildings For Potential Seismic Hazards," no. 6.
[15] D. Kurniati and P. B. Loko, "PUSHOVER STUDY ANALYSIS OF PGRI FACULTY OF ENGINEERING BUILDING," *International Journal of Engineering Technology and Natural Sciences*, 2020.
[16] FEMA, "Handbook for the Seismic Evaluation of Buildings: A Prestandard," *Fema 310*, 1998.
[17] A. R. Dista, M. Isneini, M. Helmi, T. H. Sitohang, and ..., "Efisiensi Pemilihan Jenis Retrofiting dan Perkuatan Struktur (Strengthening) antara Sistem Portal dengan Sistem Prategang Eksternal pada Jembatan Pelat Berongga …," *J. Apl. Tek. …*, vol. 18, pp. 323–328, 2020.
[18] D. Kurniati and E. F. Nurhidayatullah, "ANALISA KELAYAKAN RUMAH SEDERHANA DI YOGYAKARTA," *TAPAK (Teknologi Aplikasi Konstruksi): Jurnal Program Studi Teknik Sipil*, 2020. .
[19] Federal Emergency Management Agency (FEMA), "Rapid Visual Screening of buildings for potential seismic hazards: a handbook (FEMA P-154)," *Fed. Emerg. Manag. Agency*, no. January, p. 388, 2015, DOI: 10.4231/D3M90238V.