ARSITEKTURA
Jurnal Ilmiah Arsitektur dan Lingkungan Binaan
ISSN 2580-2976 E-ISSN 1693-3680
https://jurnal.uns.ac.id/Arsitektura/issue/archive

Volume 22 Issue 2 October 2024, pages: 325-332
DOI https://doi.org/10.20961/arst.v22i2.91696

Structural Strength of Buildings at the Islamic University of Indonesia Hospital

Indra Tri Saputra*, Noor Cholis Idham, Mahadevi Effia Arkan
[1]Department of Architecture, Faculty of Civil Engineering and Planning University Islam Indonesia, Yogyakarta, Indonesia
**Corresponding authors: 20512144@students.uii.ac.id*

Article history
Received: 08 Mar 2024
Accepted: 20 Oct 2024
Published: 30 Oct 2024

Abstract
The 2006 earthquake, with a magnitude of 6.3 and an epicenter in Potrobayan Hamlet, Bantul, Yogyakarta, caused significant damage to building structures in the area. This highlights the importance of structural integrity in earthquake-prone regions of Indonesia, particularly in Bantul. This study aims to analyze the structural strength of the Rumah Sakit Universitas Islam Indonesia (RS UII) against potential earthquakes over the next 50 years. This aligns with the building lifespan guidelines set by the Minister of Public Works Regulation No. 45 of 2007, which states that buildings should be evaluated and possibly repaired after 50 years. In this study, the author utilized RESIST software to assess the structural integrity of RS UII in the face of future seismic events. The results revealed weaknesses in the building's structure, indicating that it may not withstand the displacement caused by seismic loads. Therefore, structural reinforcement is necessary to enhance the building's resistance to larger earthquakes. Based on these findings, this study provides recommendations for structural improvements to ensure the hospital's earthquake resilience for the next 50 years, thus preventing significant structural damage.

Keywords: *building structure; earthquake; RESIST software; Universitas Islam Indonesia Hospital (RS UII).*

Cite this as: Saputra. I. T., Idham. N. C., Arkan. M. E. (2024). Structural Strength of Buildings at the Islamic University of Indonesia Hospital. *Article. Arsitektura : Jurnal Ilmiah Arsitektur dan Lingkungan Binaan*, 22 (2), 325-332. doi: https://doi.org/10.20961/arst.v22i2.91696

1. INTRODUCTION

1.1. Memories of the 2006 Bantul Earthquake

Yogyakarta is one of the regions in Indonesia that frequently experiences earthquakes. The most devastating earthquake occurred on May 27, 2006, with a magnitude of 6.3, causing significant damage to numerous buildings, including houses, schools, government offices, and other structures (**Figure 1**). The epicenter of the earthquake was located at the confluence of the Opak and Oya rivers in Potrobayan Hamlet, Bantul, Yogyakarta. The impact of the earthquake not only affected the Yogyakarta region but also reached Klaten in Central Java. In the 2006 earthquake, particularly in Bantul, the death toll reached 4,710 people, with a total of 109,048 houses completely destroyed, 99,009 houses severely and moderately damaged, and 202,044 houses lightly damaged (Satria Yoresta 2018). The damage to the buildings was caused by the failure of their structural systems to absorb and withstand the vertical and horizontal waves generated by the earthquake.

Figure 1. Damage to houses of Bantul residents, Yogyakarta (Source:https://communication.uii.ac.id/mengenang-gempa-jogja-2006-shadow-trauma-meski-17-tahun-berlalu-teman-tpa-ku-meninggal-gara-gara-itu/)

The earthquake that struck Bantul, Yogyakarta, is remembered as a tragic event by the people of Yogyakarta, particularly the residents of Bantul. The 2006 disaster became a dark chapter in their history and left lasting emotional scars. As a way to commemorate the event, the Yogyakarta government erected a monument at the earthquake's epicenter (**Figure 2**).

Figure 2. Inscription on the Bantul Earthquake Monument

The earthquake in that year severely damaged building structures in the Bantul area. Data shows that the failure of building structures to withstand vertical and horizontal loads from the earthquake's shocks can lead to their collapse (**Figure 3**). Putra and Mabui describe an earthquake as the sudden release of seismic wave energy (Putra, Mabui, and Wantoro 2023). Additionally, Tuwanoka and Banten explain that an earthquake is a natural phenomenon that cannot be predicted—when it will occur, how strong it will be, or how much seismic energy it will release. Earthquakes generally happen when two tectonic plates collide and shift (Tuwanakota and Banten 2021). Several factors contribute to building collapse, such as earthquake intensity, distance from the epicenter, depth of the hypocenter, and the geological conditions of the surrounding environment (Cholis Idham 2020). Designing a building structure that considers only gravitational loads without accounting for seismic loads is extremely risky, especially in earthquake-prone regions like Yogyakarta (Hendijaya 2019).

Figure 3. Structural failure of the STIE building due to shaking caused by the earthquake (Source:https://news.okezone.com/read/2020/05/27/510/2220403/tahun-tragedi-gempa-yogyakarta-berikut-cepat-tidaknya)

The failure of a building's structure to withstand loads can pose serious risks to its occupants. To ensure the performance of the building's structure, a structural analysis is needed to mitigate potential failures caused by earthquakes (Daffa Hukama 2023). This analysis helps determine the current performance condition of the building's structure. Efforts to mitigate structural failure in buildings, especially in the Bantul area, are crucial to preventing risks that could endanger occupants. Hospitals, in particular, are among the buildings that must be designed to withstand earthquakes (Gesha Gutama and Rahayu 2021).

Structural planning in earthquake-prone areas, such as Bantul, must adhere to government regulations. The regulation governing building structure requirements is SNI 2847-2019, which specifies structural concrete requirements for building structures. Following these state standards is crucial to ensuring the safety and earthquake resistance of buildings. The safety of buildings, especially those serving as shelters or infrastructure, such as hospitals, must be carefully considered in their structural design (Damik 2018).

A building is defined as a physical structure integrated with its location, serving as a space for humans to carry out religious, business, social, cultural, and other special activities (UU No. 28 of 2022). Buildings contain various structural elements, such as columns, beams, slabs, shear walls, and foundations. These elements function to receive loads acting on the structure and transfer them into the ground (Fadzilah, Riakara Husni, and Isneini 2021). For a structure to perform well under load, its design must adhere to proper calculation principles (Christian Silalahi and Tarigan 2022). Buildings that lack accurate structural calculations risk collapsing. Structures without adequate resistance to loads and seismic shocks can endanger their occupants (Purnomo, Purwanto, and Supriyadi 2014). Earthquake-resistant building design in Indonesia is regulated by the government under SNI 03-2012, which outlines "Earthquake-resistant design procedures for buildings and non-buildings."

In the building planning process, the standard lifespan of a building is generally 50 years, as regulated by the Regulation of the Minister of Public Works No. 45 of 2007 concerning Technical Guidelines for the Construction of State Buildings. This 50-year lifespan in building structure planning in Indonesia assumes the probability of structural collapse due to earthquake loads. According to the earthquake standard SNI 03-1726-2002, building and housing structures for earthquake resistance are designed based on the concept of a "design earthquake." A design earthquake refers to an earthquake that has the potential to occur once in 500 years (TR = 500 years). Typically, the design earthquake probability is set at 10% (RN = 10%) over a 50-year design lifespan for buildings (Widianto, Bambang, et al., 2015).

Hospital buildings, which require special attention in terms of earthquake-resistant structures, must be carefully planned. Thorough planning can significantly reduce the risk of structural failure (Hendra, Varan Zulkarnaen et al., 2021). Civil engineers and architects plan building structures through specialized calculations and analysis to ensure that the structures function effectively and reliably.

Building structure analysis can be conducted using software that helps assess the strength of building structures (Subianto and Sutriono 2024). In this study, the software used is RESIST, applied to analyze the structural integrity of RS UII. Researchers use RESIST as a tool to evaluate the strength of the existing structures.

A hospital is a building or health facility that requires special consideration regarding safety, comfort, health, and convenience (Yanto, Imani, and Andika 2019). RS UII is one of the hospitals located in the Bantul administrative area and serves as a key health centre in the region. RS UII was inaugurated on September 29, 2019, by Sri Sultan Hamengku Buwono X. Being located in Bantul, RS UII faces disaster risks, including earthquakes. A thorough understanding of earthquake-resistant building structures is crucial for the safety of both users and the health facilities within (Adianto 2018).

Previous studies have used software such as SAP2000 and ETABS to analyze the strength of building structures; however, no research has specifically focused on using RESIST software. RESIST offers advantages in terms of analysis accuracy and more efficient dynamic simulation capabilities. Past studies often encountered challenges with data input, such as needing to redesign the building structure. The use of RESIST in structural analysis addresses this issue by utilizing existing tools. Additionally, RESIST can directly suggest necessary structural improvements, such as adding columns or shear walls, to enhance a building's earthquake resistance. This study aims to analyze the strength of building structures and demonstrate how RESIST can improve structural quality by offering accurate analysis and recommendations. The goal is to ensure that the RS UII building can avoid structural damage from earthquakes over the next 50 years.

This study aims to analyze the structure of the RS UII building by utilizing simulation technology from RESIST software. RESIST can be used to evaluate the strength of existing structures or initial design concepts. The results of this analysis can serve as a reference or guide for evaluating the RS UII building's structural integrity with a 50-year projection. By conducting this study, we aim to highlight the importance of analyzing multi-story building structures and contribute to earthquake disaster risk mitigation efforts in the Bantul area.

2. METHODS

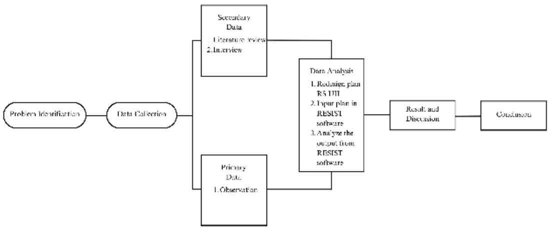


Figure 4. Research Flowchart

In this study, researchers used RESIST software to analyze the building structures at RS UII (**Figure 4**). RESIST is a computer program used by designers to determine the number and size of vertical load-bearing elements in a building. It is used to analyze vertical elements such as columns, beams, walls, and shear walls, assessing their ability to withstand wind and earthquake loads.

The first step taken by the researchers was to model the existing building structure based on primary data in the RESIST software. This involved creating an accurate model of the structural elements by considering the actual conditions and geometry. Once the structural model was created in RESIST, it was analyzed dynamically. The software produced output indicating whether the structure could withstand loads caused by earthquakes and wind forces.

The results of the RESIST analysis were then evaluated to assess the performance of the RS UII building structure over the next 50 years, specifically in terms of earthquake resistance. This involved interpreting the data to determine the strength of the existing structure and whether it could endure seismic shocks over the projected time frame.

Data collection in this study involved gathering both primary and secondary data. Primary data was obtained through direct observation and field surveys, collecting information about the characteristics of the RS UII building structure, materials used, structural dimensions, and the condition of the existing structure. Tools such as cameras and working drawings (if available) were used to aid primary data collection. After obtaining primary data, secondary methods were used to gather additional information through literature reviews from credible sources.

3. RESULT AND DISCUSSION

3.1. The Existing UII Hospital

RS UII, located in Bantul, Yogyakarta, is a hospital that was inaugurated in 2019 to provide health services, supported by expert medical professionals and equipped with sophisticated, modern technology. Researchers found that the structural system used in RS UII is a reinforced concrete structure, featuring columns measuring 50x50 cm with a 6-meter span (**Figure 5**).

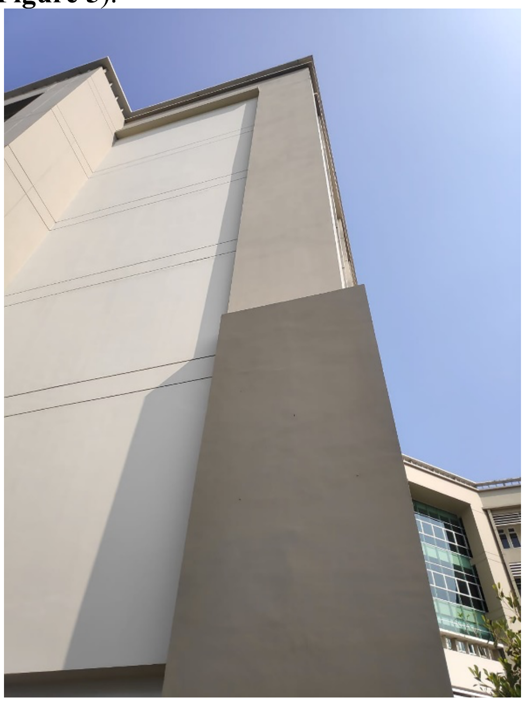


Figure 5. Column at UII Hospital
(Source: Author, 2024)

After obtaining the span and column size data, the researcher created a working drawing using

ArchiCAD software (**Figure 6**) to facilitate the analysis of column placement. It was found that the building mass at RS UII covers an area of 2,302 m². This area is designated for patient care and inpatient services at RS UII.

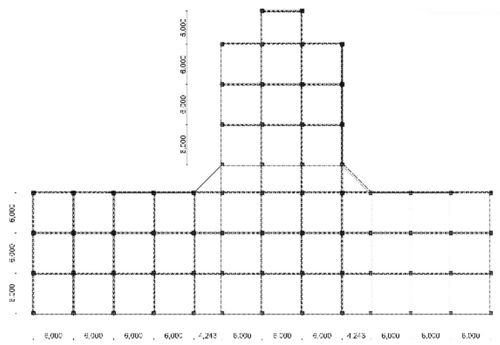
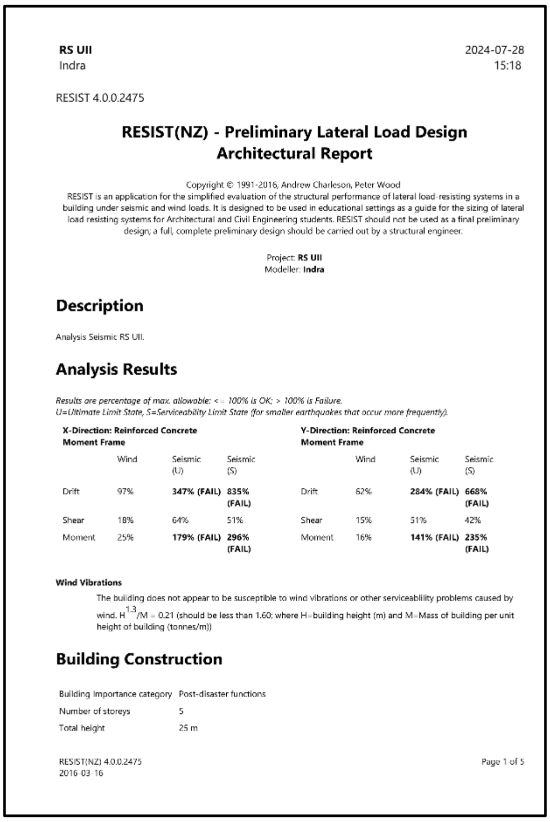


Figure 6. The design plan for UII Hospital is based on an analysis using ArchiCAD software (Source: Author, 2024)

RS UII consists of five floors and one basement. The second to fifth floors are designated for inpatient rooms, while the first floor (ground floor) is used for the lobby area and the emergency room.

3.2. RESIST Result for UII Hospital



RS UII 2024-07-28
Indra 15:18

RESIST 4.0.0.2475

RESIST(NZ) - Preliminary Lateral Load Design Architectural Report

Copyright © 1991-2016, Andrew Charleson, Peter Wood
RESIST is an application for the simplified evaluation of the structural performance of lateral load-resisting systems in a building under seismic and wind loads. It is designed to be used in educational settings as a guide for the sizing of lateral load resisting systems for Architectural and Civil Engineering students. RESIST should not be used as a final preliminary design; a full, complete preliminary design should be carried out by a structural engineer.

Project: **RS UII**
Modeller: **Indra**

Description

Analysis Seismic RS UII.

Analysis Results

Results are percentage of max. allowable: <= 100% is OK; > 100% is Failure.
U=Ultimate Limit State, S=Serviceability Limit State (for smaller earthquakes that occur more frequently).

X-Direction: Reinforced Concrete Moment Frame

	Wind	Seismic (U)	Seismic (S)
Drift	97%	**347% (FAIL)**	**835% (FAIL)**
Shear	18%	64%	51%
Moment	25%	**179% (FAIL)**	**296% (FAIL)**

Y-Direction: Reinforced Concrete Moment Frame

	Wind	Seismic (U)	Seismic (S)
Drift	62%	**284% (FAIL)**	**668% (FAIL)**
Shear	15%	51%	42%
Moment	16%	**141% (FAIL)**	**235% (FAIL)**

Wind Vibrations

The building does not appear to be susceptible to wind vibrations or other serviceablility problems caused by wind. $H^{1.3}/M$ = 0.21 (should be less than 1.60; where H=building height (m) and M=Mass of building per unit height of building (tonnes/m))

Building Construction

Building Importance category	Post-disaster functions
Number of storeys	5
Total height	25 m

RESIST(NZ) 4.0.0.2475
2016-03-16 Page 1 of 5

Figure 7. Structural analysis results using RESIST software

The results of the structural performance analysis of RS UII against lateral loads, conducted using RESIST software post-disaster for a five-story building with a total height of 25 m (**Figure 7**), show that in the X direction (Reinforced Concrete Moment Frame), the lateral displacement (drift) due to wind loads remains within the permissible limit at 97%. However, significant failure occurs under seismic loads, with displacement reaching 347% in the Ultimate Limit State (U) condition and 835% in the Serviceability Limit State (S) condition (**Figure 8**). The shear force in this direction remains within the safe limit for all load conditions, while the moment is only within safe limits for wind loads at 25%, but fails under seismic loads with values of 179% (U) and 296% (S).

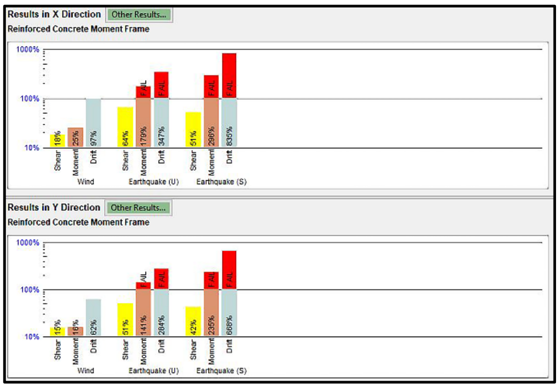
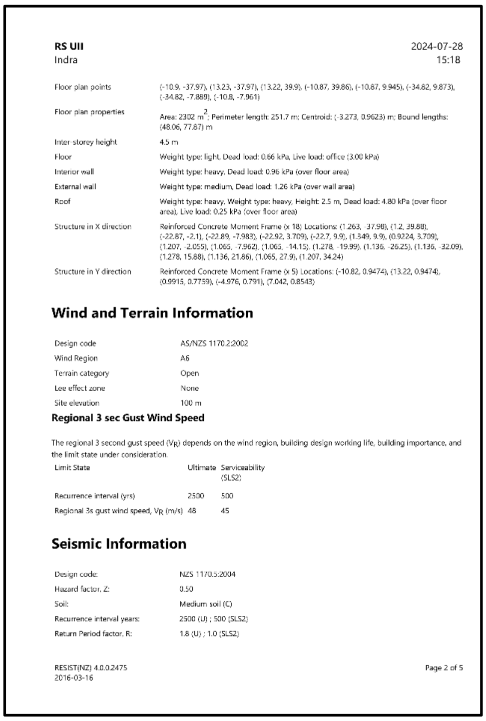


Figure 8. Diagram of the structural analysis results of the UII Hospital building using RESIST software
(Source: Author, 2024)

For the Y direction (Reinforced Concrete Moment Frame), the lateral displacement due to wind loads, at 62%, remains within the safe limit. However, the displacement due to seismic loads reaches 284% (U) and 668% (S), indicating failure. The shear force in this direction is also within the safe limit for all load conditions, with maximum values of 51% (U) and 42% (S). The moment in the Y direction shows failure under seismic loads, with values of 141% (U) and 235% (S), although it remains within the safe limit for wind loads at 16%. Wind vibration analysis indicates that the building is not susceptible to wind vibrations or related issues, with a ratio of 0.21, well below the recommended limit of 1.60. Based on these results, it can be concluded that the building's structural design is inadequate to withstand seismic loads and requires revision to ensure optimal safety and performance, particularly for earthquake mitigation over the next 50 years.

The analyzed building has a floor area of 2,302 m², a perimeter length of 251.7 m, and a floor height of 4.5 m. The floor structure consists of a dead load of 0.66 kPa and a live load of 3.00 kPa. Internal walls have a dead load of 0.96 kPa, while external walls have a dead load of 1.26 kPa. The roof is a heavy type with a dead load of 4.80 kPa and a live load of 0.25 kPa. The structural system uses a Reinforced Concrete Moment Frame with 18 locations in the X direction and 5 locations in the Y direction (**Figure 9**).



RS UII 2024-07-28
Indra 15:18

Floor plan points	(-10.9, -37.97), (13.23, -37.97), (13.22, 39.9), (-10.87, 39.86), (-10.87, 9.945), (-34.82, 9.873), (-34.82, -7.889), (-10.8, -7.961)
Floor plan properties	Area: 2302 m^2; Perimeter length: 251.7 m; Centroid: (-3.273, 0.9623) m; Bound lengths: (48.06, 77.87) m
Inter-storey height	4.5 m
Floor	Weight type: light, Dead load: 0.66 kPa, Live load: office (3.00 kPa)
Interior wall	Weight type: heavy, Dead load: 0.96 kPa (over floor area)
External wall	Weight type: medium, Dead load: 1.26 kPa (over wall area)
Roof	Weight type: heavy, Weight type: heavy, Height: 2.5 m, Dead load: 4.80 kPa (over floor area), Live load: 0.25 kPa (over floor area)
Structure in X direction	Reinforced Concrete Moment Frame (x 18) Locations: (1.263, -37.98), (1.2, 39.88), (-22.87, -2.1), (-22.89, -7.983), (-22.92, 3.709), (-22.7, 9.9), (1.349, 9.9), (0.9224, 3.709), (1.207, -2.055), (1.065, -7.962), (1.065, -14.15), (1.278, -19.99), (1.136, -26.25), (1.136, -32.09), (1.278, 15.88), (1.136, 21.86), (1.065, 27.9), (1.207, 34.24)
Structure in Y direction	Reinforced Concrete Moment Frame (x 5) Locations: (-10.82, 0.9474), (13.22, 0.9474), (0.9915, 0.7759), (-4.976, 0.791), (7.042, 0.8543)

Wind and Terrain Information

Design code	AS/NZS 1170.2:2002
Wind Region	A6
Terrain category	Open
Lee effect zone	None
Site elevation	100 m

Regional 3 sec Gust Wind Speed

The regional 3 second gust speed (V_R) depends on the wind region, building design working life, building importance, and the limit state under consideration.

Limit State	Ultimate	Serviceability (SLS2)
Recurrence interval (yrs)	2500	500
Regional 3s gust wind speed, V_R (m/s)	48	45

Seismic Information

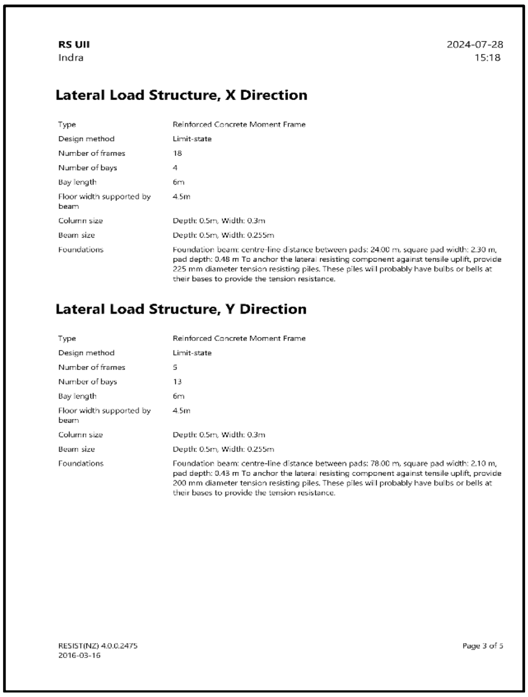
Design code:	NZS 1170.5:2004
Hazard factor, Z:	0.50
Soil:	Medium soil (C)
Recurrence interval years:	2500 (U) ; 500 (SLS2)
Return Period factor, R:	1.8 (U) ; 1.0 (SLS2)

RESIST(NZ) 4.0.0.2475 Page 2 of 5
2016-03-16

Figure 9. Results of the technical parameter analysis of buildings using RESIST

Wind and terrain data indicate that the design falls into the open terrain category, with the site elevation at 100 m. The 3-second regional wind speed (VR) is determined based on the wind region, the design life of the building, and the limit conditions considered, with wind speeds of 48 m/s for the Ultimate condition and 45 m/s for the Serviceability condition.

For seismic data, the earthquake recurrence interval is set at 25 years for the Ultimate condition and 50 years for the Serviceability condition, with a return period factor of 1.8 for the Ultimate condition and 1.0 for the Serviceability condition. In the RS UII building, which uses a Reinforced Concrete Moment Frame, the input data was analyzed using RESIST software (**Figure 10**). In the X direction, the structure consists of 18 frames with 4 spans, each measuring 6 meters in length, and a floor width supported by beams spanning 4.5 meters. The columns have a depth of 0.5 meters and a width of 0.3 meters, while the beams have a depth of 0.5 meters and a width of 0.255 meters. The foundation consists of a foundation beam with a distance of 24 meters between the center supports, a support width of 2.3 meters, and a support depth of 0.48 meters. To withstand tensile forces, a retaining pole with a diameter of 225 mm is used, which may feature a ball or bell at the base to increase resistance.



RS UII 2024-07-28
Indra 15:18

Lateral Load Structure, X Direction

Type	Reinforced Concrete Moment Frame
Design method	Limit-state
Number of frames	18
Number of bays	4
Bay length	6m
Floor width supported by beam	4.5m
Column size	Depth: 0.5m, Width: 0.3m
Beam size	Depth: 0.5m, Width: 0.255m
Foundations	Foundation beam: centre-line distance between pads: 24.00 m, square pad width: 2.30 m, pad depth: 0.48 m To anchor the lateral resisting component against tensile uplift, provide 225 mm diameter tension resisting piles. These piles will probably have bulbs or bells at their bases to provide the tension resistance.

Lateral Load Structure, Y Direction

Type	Reinforced Concrete Moment Frame
Design method	Limit-state
Number of frames	5
Number of bays	13
Bay length	6m
Floor width supported by beam	4.5m
Column size	Depth: 0.5m, Width: 0.3m
Beam size	Depth: 0.5m, Width: 0.255m
Foundations	Foundation beam: centre-line distance between pads: 78.00 m, square pad width: 2.10 m, pad depth: 0.43 m To anchor the lateral resisting component against tensile uplift, provide 200 mm diameter tension resisting piles. These piles will probably have bulbs or bells at their bases to provide the tension resistance.

RESIST(NZ) 4.0.0.2475 Page 3 of 5
2016-03-16

Figure 10. Result of data input into RESIST for analysis

In the Y direction, the structure consists of 5 frames with 13 spans, each measuring 6 meters in length, and a floor width supported by beams spanning 4.5 meters. The sizes of the columns and beams are the same as those in the X direction. The foundation in this direction has a distance of 78 meters between the center supports, with a support width of 2.1 meters and a support depth of 0.43 meters. To withstand tensile forces, a retaining pole with a diameter of 200 mm is used, which may also feature a ball or bell at the base. The design method used is the limit-state method, which considers the maximum conditions that the structure can safely endure under both ultimate and serviceability conditions.

4. CONCLUSION

The results of the analysis conducted by researchers using RESIST software indicate that while the RS UII building can withstand wind loads, it is not capable of withstanding seismic loads. Therefore, it is necessary to reconsider and re-evaluate the structural design of RS UII, particularly given its location in an earthquake-prone area. The structural integrity of the building is crucial, especially in the Bantul region, where seismic activity must be accounted for to ensure that the building can endure such loads.

The purpose of this review is to analyze the existing structure to ensure the safety of users, as hospitals are vital community facilities. The performance of the RS UII building in the event of future earthquakes, which could potentially have greater magnitudes than previous ones, needs to be addressed, particularly in projections over the next 50 years. Additionally, an earthquake mitigation program is essential, especially for buildings like RS UII, which serves a critical emergency function.

One of the key aspects of earthquake mitigation is designing structures to be earthquake-resistant by incorporating modern technologies, such as seismic isolators and shear wall systems. By implementing such measures, RS UII and other buildings in earthquake-prone areas like Bantul can prevent collapses similar to those that occurred in 2006.

ACKNOWLEDGEMENT

The author would like to thank all those who provided information regarding the 2006 earthquake, especially Mr. Sugio, the head of Kalangan Hamlet, and the residents of Kanten Hamlet for their contributions to this research.

REFERENCES

Adianto, Bobby, M Yusuf, and Yoke Lestyowati. (2018). PERHITUNGAN STRUKTUR BETON BERTULANG RUMAH SAKIT 8 LANTAI UNIVERSITAS TANJUNGPURA PONTIANAK. JeLAST: Journal Teknik Kelautan, PWK, Sipil, dan Tambang, 5(3). http://dx.doi.org/10.26418/jelast.v5i3.30517

Cholis Idham, Noor. (2020). Earthquake Disaster Mitigation in the Building Industry. Journal of Arhcitectural Research and Design Studies, 4(2), 86-95. https://doi.org/10.20885/jars.vol4.iss2.art11

Christiani Silalahi, Hernawati, and Johannes Tarigan. (2022). Analisis Ketahanan Struktur Atas Rumah Instan Sederhana Sehat Dengan Perhitungan Beban Gempa Di Upgrade 3 (Tiga) Lantai. *Jurnal Syntax Admiration* 3(11): 1412–24. https://doi.org/10.46799/jsa.v3i11.505

Daffa Hukama, Raihan. (2023). Analisis Kekuatan Struktur Pada Bangunan 8 Lantai Berdasarkan Respon Spektrum SNI 03-1726-2019 Menggunakan SAP2000. J-SIL: Jurnal Teknik Sipi dan Lingkungan, 8(3), 127-136. https://doi.org/10.29244/jsil.8.3.127-136

Damanik., Andre, Obrian, Wibowo., A.S Arif, Wibowo., Hardi, P. Yulita Arni. (2018). "PERENCANAAN STRUKTUR GEDUNG RUMAH SAKIT SILOAM, SEMARANG." JURNAL KARYA TEKNIK SIPIL, 7(1), 29-38.

Fadzilah, Masrifatun, Hasti Riakara Husni, and Mohd Isneini. (2021). Evaluasi Kekuatan Struktur Gedung Bertingkat Akibat Pengaruh Beban Gempa Menggunakan Analisis Dinamik Respon Spektrum (Studi Kasus: Gedung B Rumah Sakit Umum Muhammadyah Metro). JRSDD: Journal Rekayasa Sipil Dan Desain, 9(4), 605-622.

Gesha Gutama, Dhani, and Rita Laksmitasari Rahayu. (2021). L A K A R KETAHANAN BANGUNAN RUMAH SAKIT TERHADAP BENCANA GEMPA BUMI DI BANTUL DAERAH ISTIMEWA YOGYAKARTA. Lakar: Jurnal Arsitektur, 4(2), 150-159. http://dx.doi.org/10.30998/lja.v4i2.10958

Hendijaya, Fery. (2019). ANALISIS STRUKTUR BANGUNAN TERHADAP BEBAN HORIZONTAL PADA

GEDUNG RAWAT INAP RUMAH SAKIT DADI TJOKRO DIPO BANDAR LAMPUNG. *Jurnal Teknika Sains*. 4(1), 17-24. https://doi.org/10.24967/teksis.v4i1.635

Purnomo, Edy, Edy Purwanto, and Agus Supriyadi. (2014). ANALISIS KINERJA STRUKTUR PADA GEDUNG BERTINGKAT DENGAN ANALISIS DINAMIK RESPON SPEKTRUM MENGGUNAKAN SOFTWARE ETABS (STUDI KASUS : BANGUNAN HOTEL DI SEMARANG).

Putra, Mahdika, Didik Mabui, and Mamik Wantoro. (2023). EVALUASI KINERJA BANGUNAN GEDUNG REKTORAT UNIVERSITAS YAPIS PAPUA AKIBAT PENGARUH GEMPA DI JAYAPURA." *Cyclops : Jurnal Teknik Sipil Dan Perencanaan* 1 (2): 63–74. https://doi.org/10.55098/jtsp.v1i2.492.

Satria Yoresta, Fengky. (2018). Analisis Ketahanan Gempa Rumah Tembokan Beton Bertulang Di Perumahan Graha Arradea. *54 Media Komunikasi Teknik Sipil*. 24(1), 54-61. https://doi.org/10.14710/mkts.v24i1.18097

Subianto, Yusub Ahmad., and Sutriono Bantot. (2024). STRUCTURAL STRENGTH EVALUATION OF SUMBEREJO HOSPITAL BUILDING WITH EARTHQUAKE LOADING SNI 03-1726-2002 AND SNI 03-1726-2019 USING PUSHOVER METHOD. Journal of Scientech Research and Development, 6(1), 460-470. https://doi.org/10.56670/jsrd.v6i1.333

Tuwanakota, Epafroditus, and Christianto P Banten. (2021). ANALISIS KEKUATAN STRUKTUR BERDASARKAN RESPON SPEKTRUM TERHADAP GAYA GEMPA YANG AKAN DATANG DI KOTA SORONG. Jurnal Karkasa, 7(2), 62-71. https://doi.org/10.32531/jkar.v7i2.423

Varan Zulkarnaen, Lio, Indah Rosanti, Rona Ariyansyah. (2021). ANALISIS STRUKTUR GEDUNG TAHAN GEMPA DENGAN METODE SISTEM GANDA (DUAL SYSTEM). CAM: Journal Construction and Material, 3(3), 189-196. https://doi.org/10.32722/cmj.v3i3.4205

Widianto Bambang, Alwi Abubakar, Rustamaji RM. (2015). Kajian Ketentuan Pembuatan Pedoman Pengoperasian, Pemeliharaan dan Perawatan Bangunan Gedung. 15(2), 392-400.

Yanto, Nugrafindo, Rafki Imani, and Zulva Andika. (2019). Evaluasi Kinerja Struktur Gedung Rumah Sakit Paru Sumatera Barat Dengan Pushover Analysis. CEC: Journal Civil Engineering Collaboration, 4(2), 1-9. https://doi.org/10.35134/jcivil.v4i2.1