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Analysis of Green Concrete Structure of 2-Storey High-rise Building at Airport Based on SAP2000 V22 Application

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ABSTRACT

Waste is the residue of daily human activities. Waste tends to be able to cause ecological crises and trigger the development of diseases in humans. Therefore, waste needs to be recycled, especially inorganic waste. The current waste recycling process can be used as an aggregate replacement building material, and several tests have been carried out is green concrete. Experimentally, green concrete has been tested with results when replacing 5% fine aggregate has a percentage of concrete strength of 97.4% against normal concrete. Green concrete needs to be structurally analyzed before being tested in manufacturing simple-level buildings. The analysis process is carried out with the SAP 2000 V22 application as a simulator of structural behavior based on parameters related to green concrete. This analysis aims to evaluate the accuracy of reliability, and performance of the building structure. This study uses the LRFD (Load and Resistance Factor Design) method to determine the load received by the structure by considering the resistance factor of the material used. The results of this study show that the three simulations of concrete data with compressive strengths of 17 Mpa, 19 Mpa, and 20 Mpa have no structural irregularities and are safe to use. However, using 19 Mpa and 20 Mpa structural concrete is still recommended. This is because the mechanical characteristics of concrete are not only determined by compressive strength, but there are other factors, such as flexural strength, shear strength, modulus of elasticity, and other physical properties.

INTRODUCTION

In recent decades, awareness of sustainability and environmental protection has rapidly increased worldwide. This has led to innovations in environmentally friendly construction technologies and techniques. Among the latest innovations is using environmentally friendly building materials such as green concrete, which has a lower impact than conventional concrete on the environment. Inorganic waste can create severe effects on environmental pollution with very long decomposition. The consequences will be concerning for life in the long term, which can cause ecological crises, such as the emergence of typhus, smallpox, dysentery, and so on (Desy & Nova, 2018). Based on data from the Ministry of Environment and Forestry, the amount of waste in Indonesia is currently 187.2 million tons per year (Risnawati et al., 2021). This waste can be processed through recycling by processing unused goods or objects into usable objects (Susanto et al., 2020).

A response to environmental challenges and the need for sturdy and durable building structures, especially in environments prone to earthquakes, the planning and analysis of building structures have become very important. In this regard, structural software such as SAP2000 (Structural Analysis Program) has become imperative to ensure that building structures meet the required safety and strength standards. Research (Annajma Junia, 2023) suggests that the need for infrastructure increases as the population increases. Using building materials from nature, such as coarse aggregate (gravel), fine aggregate (sand), and other materials in manufacturing concrete as a building material, is increasingly needed. Inorganic waste has become an interesting topic in recent years to find the best solution, such as research (Setiawan, 2017) that utilizes residues from the combustion of inorganic waste, such as plastic and cloth, to replace fine aggregates in building material mixtures. Several tests have been conducted to see the effectiveness of concrete properties, including strength, stiffness, permeability, and durability when operating. One of them is research (Masril, 2021) analyzing the effect of the addition of plastic waste aggregates of the Polyethylene Terephthalate type on the compressive strength of concrete. The results of this study show that the greater the percentage of plastic waste used in concrete mixtures, the more the compressive strength and quality of the resulting concrete will increase.

Green Concrete is an environmentally friendly concrete composed of recycled materials from several inorganic waste mixtures as a substitute for fine aggregate (Putri & Tobing, 2019). It is essential to know that green concrete can be applied to simple-level buildings (Al-Mansour et al., 2019). However, before being applied to building structures, it is vital to analyze the loads acting on the building, for example, Earthquake Load, Wind Load, Dead Load, and Live Load (Martayase, 2022). This aims to keep the building sturdy and not experience collapse due to cyclic and lateral forces acting on the building. The strength of the building structure can be seen using the SAP 2000 Version 20 application, which is designed using green concrete using a 3D model (Ghifari, 2020). So that the concrete structure applied to a simple level building can be carefully planned and the strength of the building is as expected.

Within this context, constructing a two-story high-rise building at the airport requires careful structural analysis to ensure the safety and comfort of passengers and airport crew (Mandasari, 2019). Therefore, the research aims to analyze the structure of a two-story high-rise building in an airport using green concrete as the primary material. This research is also supported by applying SAP2000 software to check the reliability and strength of the building structure for loading (Mahendra et al., 2022). A comprehensive analysis will be conducted to assess the performance of the green concrete structure in an airport environment and ensure that it meets all necessary safety and sustainability requirements. Combining the latest technological innovations in construction materials with advanced structural analysis methods, this research is expected to provide new knowledge regarding the potential use of green concrete in constructing two-story buildings at airports. In addition, the results of this study can provide practical guidelines for engineers and related professionals to develop environmentally friendly and durable structural solutions in similar construction projects in the future.

METODE

This research was conducted by analyzing the difference between conventional concrete and green concrete. Some data was obtained by doing several stages, including (1) Research design, (2) Data and sample collection, (3) Determination of green concrete material parameters, (4) Modeling of simple building structures in SAP, (5) Structural loading; (6) Linear and nonlinear static analysis; (7) Selection of dynamic analysis methods; (8) Interpretation of analysis results. In carrying out research, it is imperative to represent graphics and workflows to facilitate understanding through flowcharts. The flowchart can be seen in Figure 1.

Figure 1. Research Flow Chart

a. SAP 2000

This research uses the structural analysis method with SAP (Structure Analysis Program) 2000 V22 software. The software was chosen to analyze the structural behavior of a simple-level building with concrete material. SAP 2000 is a well-known and frequently used software in structural analysis and building design (Zega et al., 2022). The selection of SAP 2000 as an analysis tool is based on various factors, including (1) Comprehensive and modular with the ability to model types of structures with varying levels of complexity; (2) Simulator of metallic materials as realistic as possible during parameter analysis; (3) Static and dynamic analysis capabilities with different load structure responses; (4) Nonlinear analysis with modeling of material behavior that can undergo large deformations; (5) Has the best result visualization capabilities. Utilizing the features of the SAP 2000 application is suitable for analyzing structures with concrete materials, including in this research aimed at green concrete. SAP 2000 allows in-depth simulation of structural behavior based on parameters related to green concrete, thus enabling accurate evaluation of structural reliability and performance (Hasibuan, 2022). Furthermore, the Load and Resistance Factor Design (LRFD) method is used in engineering building structural design. The system determines the load acceptance in a structure by calculating the resistance factor and strength of the materials used (Putra, 2023).

b. Research Design

This research adopts an experimental analysis approach using SAP 2000 software to analyze the structure of a simple multi-level building using concrete materials. The research design integrates structural analysis with the concept of green concrete, which is expected to generate information about the structural behavior and reliability of this new material (Fistcar, 2021) as shown in Figure 2.

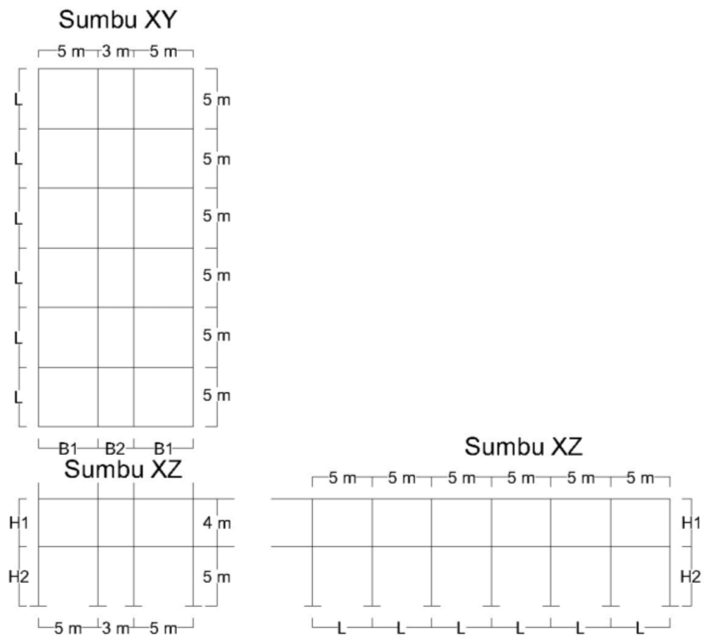
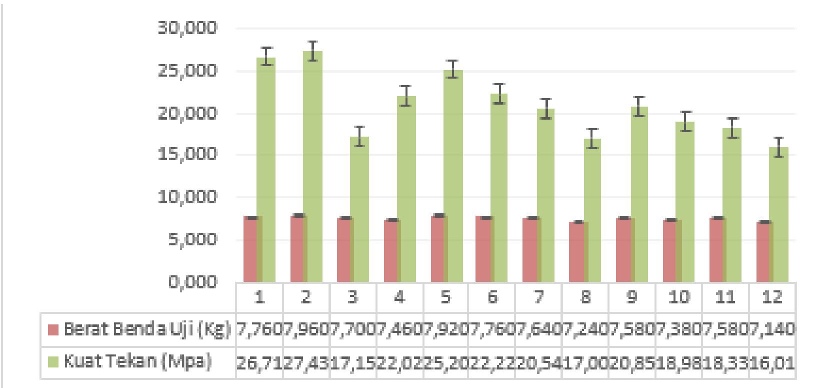


Figure 2. 2-Story Frame Portal Design

RESULT AND DISCUSSION

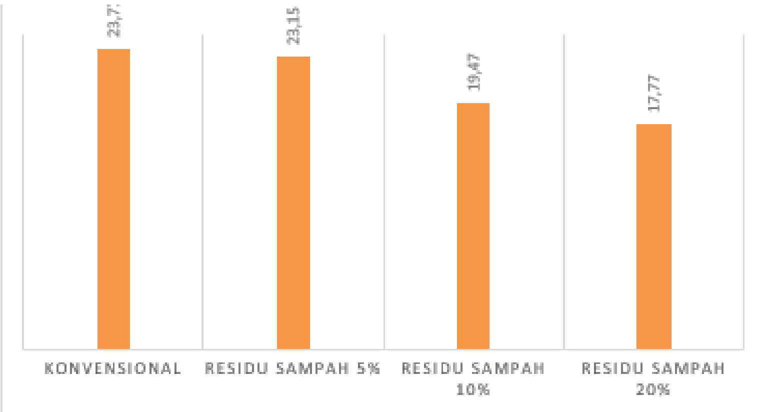
Previous research data compared conventional concrete and sample 1, with a green concrete compressive strength of 19 Mpa, and sample 2, with a compressive strength of 17 Mpa.

a. Determination of Green Concrete Material Parameters



Data processed (2023)
Figure 3. Concrete Compressive Strength Chart as a Comparison Indicator

In Figures 3 and 4, data analysis of indicators of comparison of concrete compressive strength tests of several samples with test concrete numbers:
- 1,2,3 = Normal Concrete
- 4,5,6 = 5% Waste Residue
- 7,8,9 = 10% Waste Residue
- 10,11,12 = 20% Waste Residue



Data processed (2023)
Figure 4. Graph of Average Compressive Strength (Mpa)

From the above data, compressive strength samples were taken to analyze the comparison of green concrete quality to normal concrete: concrete F'c = 20 MPa as conventional concrete and concrete F'c = 19 MPa and 17 Mpa (green concrete).

b. Dimensions and Specifications of Structural Elements

In determining the building structure, the following dimensional specifications were selected:
- Beam = 30/40 cm
- Column = 40/40 cm
- Roof Plate = 10 cm

Floor Plate = 12 cm Thickness Membrane & Bending 12 cm / 0.12 m

c. LRFD Method

Analysis of an office building with a comparison between conventional concrete and Green Concrete as an innovation to decompose plastic and fabric waste with a replacement of fine aggregate in the concrete mix. This case study is planned in Palembang City (Earthquake Load). Based on the following data:
- Normal Concrete with compressive strength F'c=20 Mpa
- Green Concrete A with compressive strength F'c = 17 Mpa
- Green Concrete B with compressive strength F'c = 19 Mpa

Using spectrum response, the Load and Resistance Factor Design (LRFD) method was used to analyze the same portal frame with 2-story office specifications. This method was a significant consideration in maintaining the need for more structural strength and anticipating the overloading of the building. In addition, this method effectively considers factors such as load factors, boundary conditions, and resistance factors (Sila et al., 2023).

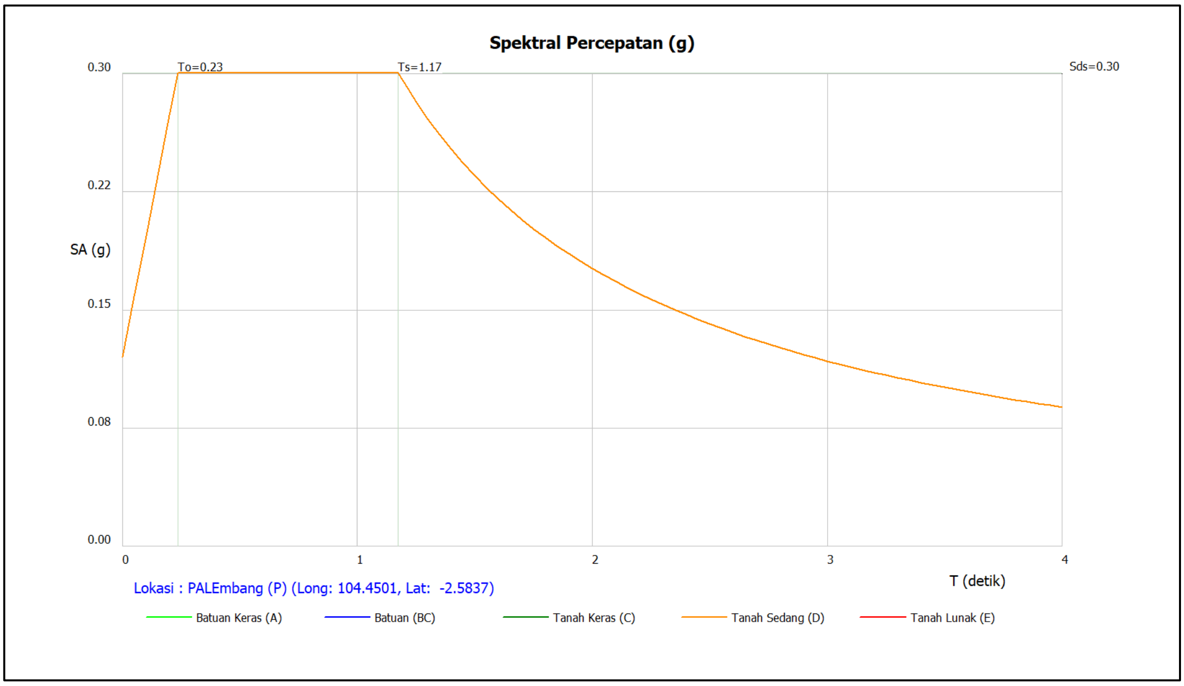
d. Determination of Earthquake Area Zone

In searching for Response Spectrum Data, it can be accessed on the Indonesian Spectrum Design website (pu.go.id) with a case study of Palembang city to obtain visualizations such as Figure 5, and select plan data on Medium Soil conditions, then exported in the form of Microsoft Excel (.xlsx) and Notepad (.txt). The location of Palembang City is at the coordinates of Latitude: -2.983333 and Longitude: 104.783333 (shown in Table 1).

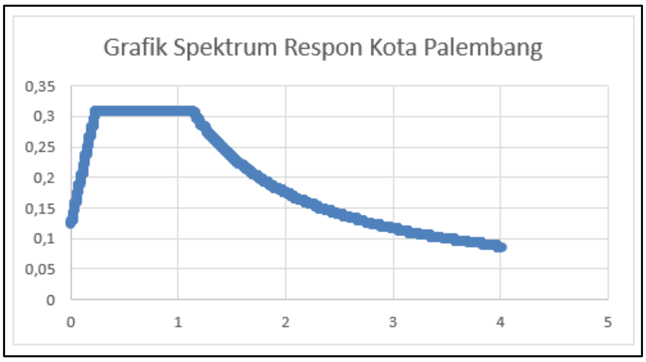
Table 1. Spectra Design Information Palembang City

Class	T0	Ts	Sds	Sd1
SD	0,23	1,13	0,31	0,35
Longitude			104,783,333	
Latitude			-2,983,333	
pga			0,1480	
ss			0,2909	
s1			0,2485	
tl			20	
tl			20	

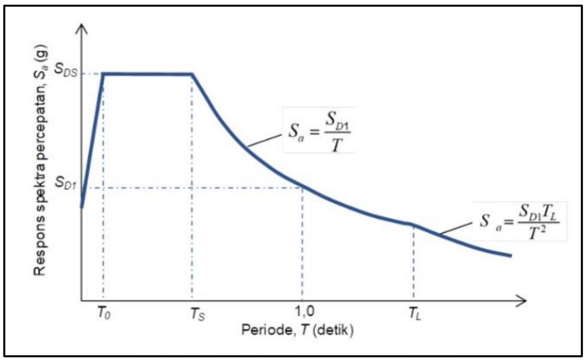
Earthquake Spectrum Data
(Source: PUSKIM PUPR 2019 software application)



(1)



(2)



(3)

T	SA
0.000	0.124
0.100	0.204
0.230	0.310
0.330	0.310
0.430	0.310
0.530	0.310
0.630	0.310
0.730	0.310
0.830	0.310
0.930	0.310
1.030	0.310
1.130	0.310
1.230	0.285
1.330	0.263

T	SA
1.430	0.245
1.530	0.229
1.630	0.215
1.730	0.202
1.830	0.191
1.930	0.181
2.030	0.172
2.130	0.164
2.230	0.157
2.330	0.150
2.430	0.144
2.530	0.138
2.630	0.133
2.730	0.128

T	SA
2.830	0.124
2.930	0.119
3.030	0.116
3.130	0.112
3.230	0.108
3.330	0.105
3.430	0.102
3.530	0.099
3.630	0.096
3.730	0.094
3.830	0.091
3.930	0.089
4.000	0.088

(4)

Figure 5. (1) Spectral Graph of Acceleration; (2) Response Spectrum Graph of Palembang City; (3) Design Response Spectrum Graph; (4) Response Spectrum Data of Earthquake Coefficient for Medium Soil Condition Palembang City

e. Concept of Loading

We need to know that an external force, referred to as a load, is acting on each structure component. This loading is one of the determining factors for structural planning; if the existing load exceeds the planned load, it will have fatal consequences for the building. Based on (SNI 1726, 2019) for Minimum Building Design Loads regarding the minimum load that can be designed on buildings and other structures based on certain specifications by the specified load combination (SNI, 2020), such as floor and roof loads, which are generally regulated as follows:

1) Dead Load:

Load from one's weight on structural and non-structural components is a dead load (Darmawan, 2021). Permanent load or fixed load because this load is always present on the structure and does not change significantly every time. Dead Load is included in the category of stable load because it does not depend on weather changes or dynamic loads.

a) Floor Load: Floor dead load includes the self-weight of the structure, fixed furniture, floor finishes, fixed partitions, and other elements that do not move on the floor.
b) Floor dead load with 1.5 kN/m².
c) Roof Dead Load: The roof dead load includes the self-weight of the roof frame, roof covering, rainwater drains, and other fixed elements.
d) Roof dead load with 0.25 kN/m².

2) Live Load:

a) Floors: Floor live loads are from human activities, movable equipment, furniture, and other daily activities on the floor. Live loads can vary depending on the type of building and its use (Bambang et al., 2018). Floors have a live load of 2.5 kN/m².
b) Roof: The live load on the roof may come from equipment or access on the roof, such as maintenance or technical equipment placed on it.
c) The live load of the roof is 1.0 kN/m².

3) Earthquake Load

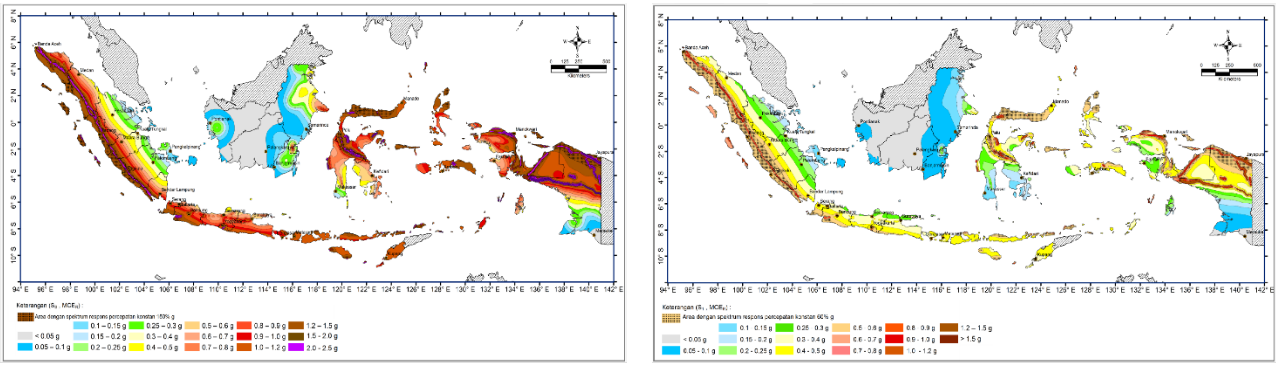
All equivalent static loads on building components due to earthquake-induced ground movement, with horizontal or vertical direction of movement, are earthquake loads. Based on the standard (SNI 1726, 2019) determines the review of planning and evaluation of structures from the effects of earthquake plans on building and non-building structures and equipment therein. Earthquake 11 is a plan with the possibility of exceeding

Volume 6 Nomor 2 Desember 2023 | halaman 61-77
DOI: http//doi.org/10.46509/ajtk.v6i2.417

the 50-year life of the building structure by 2% against the earthquake (Pangestu, 2022). With the following provisions:

a) Base Rock Earthquake Acceleration Parameters - Ss

- Ss (Period of acceleration of bedrock 0.2 seconds with a return period of 2500 years)
- S1 (Bedrock acceleration period of 1.0 seconds with a return period of 2500 years)



(1) **(2)**

Figure 6. (1) 0.2 Second Spectra Map For Earthquake Return Period; (2) 1.0 Second Spectra Map for the Earthquake Return Period
(Source: PUSKIM PUPR 2019 software application)

a) Risk Category Amplification Factor

The following is an image of the risk category table in the office building:

Jenis pemanfaatan	Kategori risiko
Gedung dan nongedung yang memiliki risiko rendah terhadap jiwa manusia pada saat terjadi kegagalan, termasuk, tapi tidak dibatasi untuk, antara lain: - Fasilitas pertanian, perkebunan, pertenakan, dan perikanan - Fasilitas sementara - Gudang penyimpanan - Rumah jaga dan struktur kecil lainnya	I
Semua gedung dan struktur lain, kecuali yang termasuk dalam kategori risiko I,III,IV, termasuk, tapi tidak dibatasi untuk: - Perumahan - Rumah toko dan rumah kantor - Pasar - Gedung perkantoran - Gedung apartemen/ rumah susun - Pusat perbelanjaan/ mall - Bangunan industri - Fasilitas manufaktur - Pabrik	II
Gedung dan nongedung yang memiliki risiko tinggi terhadap jiwa manusia pada saat terjadi kegagalan, termasuk, tapi tidak dibatasi untuk: - Bioskop - Gedung pertemuan - Stadion - Fasilitas kesehatan yang tidak memiliki unit bedah dan unit gawat darurat - Fasilitas penitipan anak - Penjara - Bangunan untuk orang jompo Gedung dan nongedung, tidak termasuk kedalam kategori risiko IV, yang memiliki potensi untuk menyebabkan dampak ekonomi yang besar dan/atau gangguan massal terhadap kehidupan masyarakat sehari-hari bila terjadi kegagalan, termasuk, tapi tidak dibatasi untuk: - Pusat pembangkit listrik biasa - Fasilitas penanganan air - Fasilitas penanganan limbah - Pusat telekomunikasi Gedung dan nongedung yang tidak termasuk dalam kategori risiko IV, (termasuk, tetapi tidak dibatasi untuk fasilitas manufaktur, proses, penanganan, penyimpanan, penggunaan atau tempat pembuangan bahan bakar berbahaya, bahan kimia berbahaya, limbah berbahaya, atau bahan yang mudah meledak) yang mengandung bahan beracun atau peledak di mana jumlah kandungan bahannya melebihi nilai batas yang disyaratkan oleh instansi yang berwenang dan cukup menimbulkan bahaya bagi masyarakat jika terjadi kebocoran.	III

Figure 7. Risk Category Table
SNI 1726-2019 Page 24-25

Because the planning design of the office building category is category 2:

Kategori risiko	Faktor keutamaan gempa, I_e
I atau II	1,0
III	1,25
IV	1,50

Figure 8. Comparison of Risk Categories and Earthquake Vulnerability Factor

The seismic force-bearing system factors for R and Cd Ω 0 follow SNI 1726-2019 regulations. with a modified office response coefficient of 5.

Related to the planned design is functional as a form of office building with risk category II, so it has a Response Modification Coefficient (R) value of = 5, Building Importance Factor (I) of = 1, and the acceleration of earth's gravity of 9.81 m / s2 (Sarah, 2022). So, it can be calculated with the following multiplier factor:

$\frac{I}{R}$ x 9,81 $= \frac{1}{5}$ x 9,81 = 1,962

Then the Scale Factor of the earthquake spectrum response = 1.962.

The treatment results are obtained by (Mukrimaa et al., 2016);

1) Dead Load
   Floor=1.5 kN/m2
   Roof=0.25 kN/m2

2) Live Load
   Floor=2.5 kN/m2
   Roof=1.0 kN/m2
   Combination of loading

For the building structure and its components to meet the strength requirements and be suitable for use in various load combinations, it must be fulfilled based on the provisions of the load factor (BSN, 2020). According to the Load Resistance Factor Design (LRFD), the Ultimate Stress method used can be calculated by combining the loadings. Therefore, the following selected combinations were used:

a) 1.4 D, For dead load condition (D) on the loaded structure.
b) 1.2D + 1.6L (Load Combination 1), with D (dead load condition) and L (live load)
c) 1.2D + 1.0L + 1.0RSx + 0.3RSy, with D (dead load condition), L (live load) with X direction spectral response earthquake load.
d) 1.2D + 1.0L + 0.3RSx + 1.0RSy, with D (dead load condition) and L (live load) in the Y direction of the spectral response earthquake load.

Based on the loading combination, a critical combination will be selected, and a combination of orthogonal direction earthquake loads imposed 100% in the main direction and 30% perpendicularly, which are reviewed for the main directions of X and Y, respectively.

ANALYSIS OF FRAME DESIGN AND MATERIAL IN SAP2000 V22

The detailed design planning specifications are analyzed with the loading behavior of the three concrete grades shown in Figure 13.

Concrete Sample Compressive Strength F'c = 20 Mpa

Structure Safety

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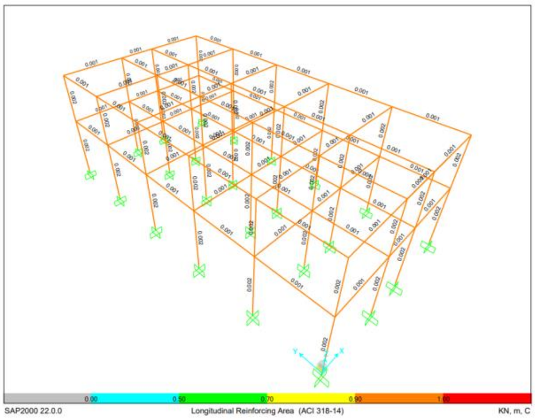
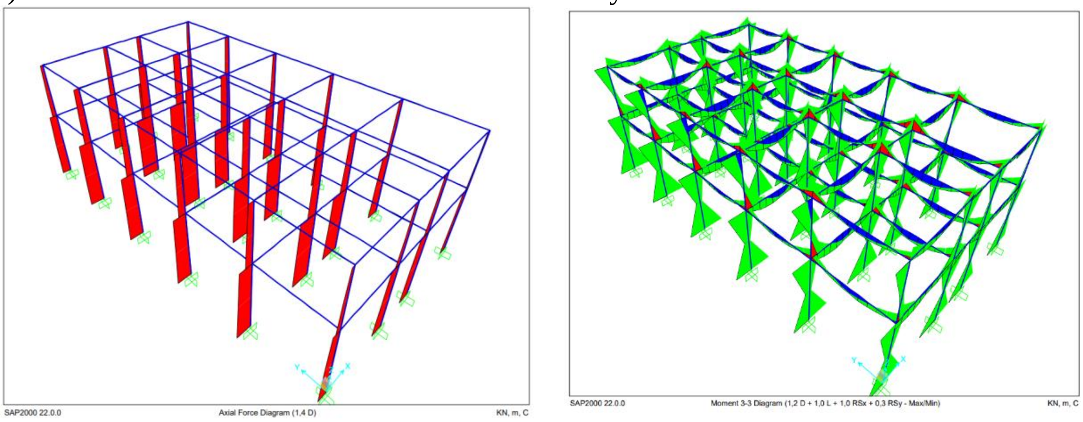


Figure 9. Check the safety structure of concrete F'c 20 Mpa

Based on the analysis of the structural results, there are no frames that experience structural failure, so the portal is feasible by using a concrete strength of 20 Mpa as a conventional concrete comparison with green concrete.

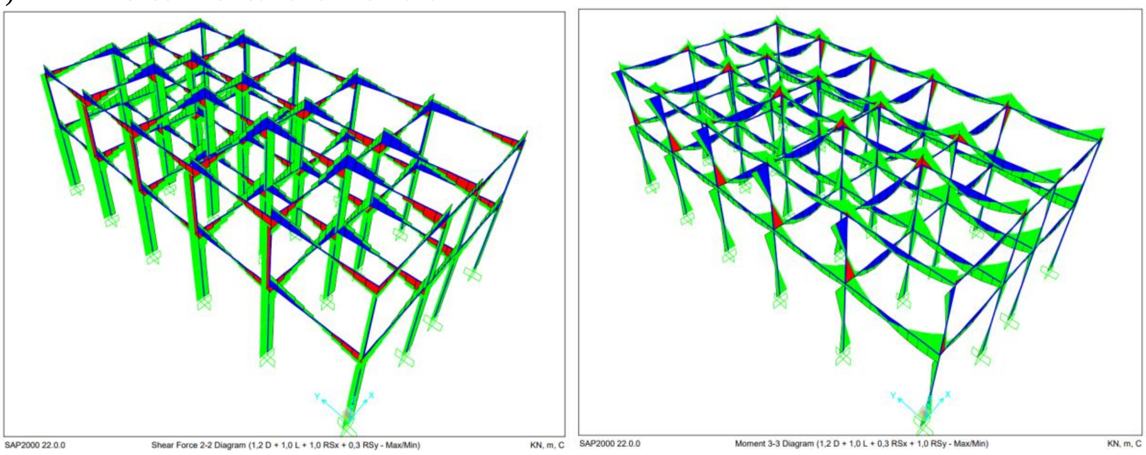
1) Axial Inside Force and Column Momentary Inside Force



(1) (2)

Figure 10. (1) Axial Inside Force (Nu), Nu = 1.4 D = 279.386 KN; (2) Column Momentary Inside Force (Muk) Muk = 1.2D + 1.0L + 1.0RSx + 0.3RSy = 8.8705 KNm

2) Force In Shear and Moment



(1) (2)

Figure 11. (1) Force In Shear (Vu), Vu = 1.2D + 1.0L + 1.0RSx + 0.3RSy = 43.121 kN; (2) Force In Moment (Mu) Mu = 1.2D + 1.0L + 0.3RSx + 1.0RSy = -48.0199 kNm

3) Force In Plate Moment

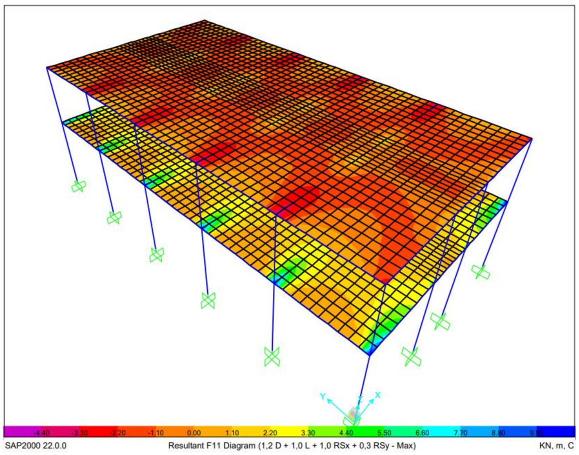


Figure 12. Force in Plate Moment (Mu)

- Min = -4.54 kNm
- Max = 10.698 KNm
- Mu = 1.2D + 1.0L + 1.0RSx + 0.3RSy = -52.4707 kNm

g. Concrete Sample Compressive Strength F'c = 20 Mpa Structure Safety

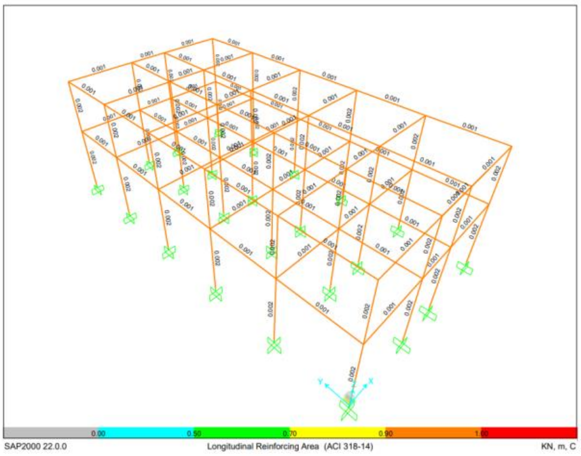
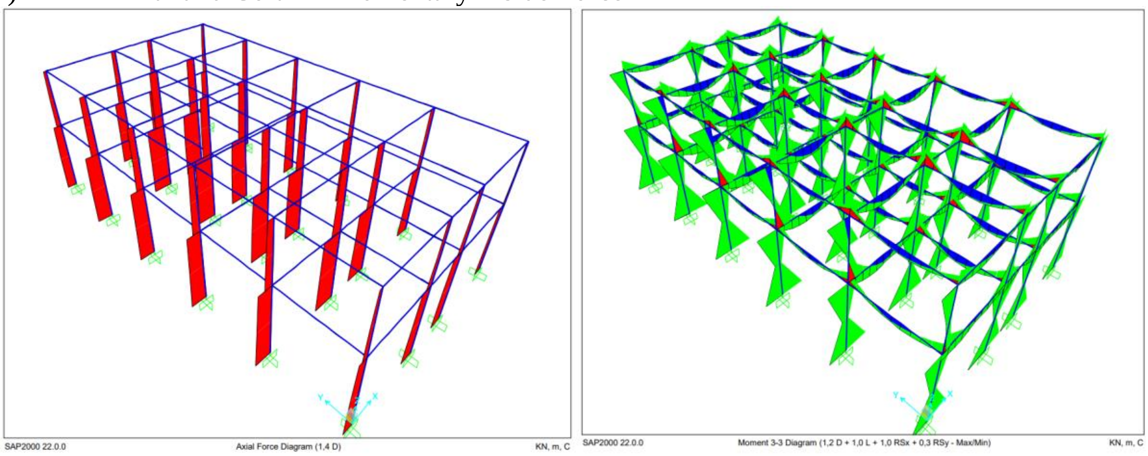


Figure 13. Structure safety check F'c 20 MPa concrete

Based on the structural analysis results, no frames experience structural failure, so the portal is feasible by using a concrete strength of 20 Mpa as conventional concrete for comparison with green concrete.

1) Axial and Column Momentary Inside Force



(1) (2)

Airman: Jurnal Teknik dan Keselamatan Transportai
Volume 6 Nomor 2 Desember 2023 | halaman 61-77
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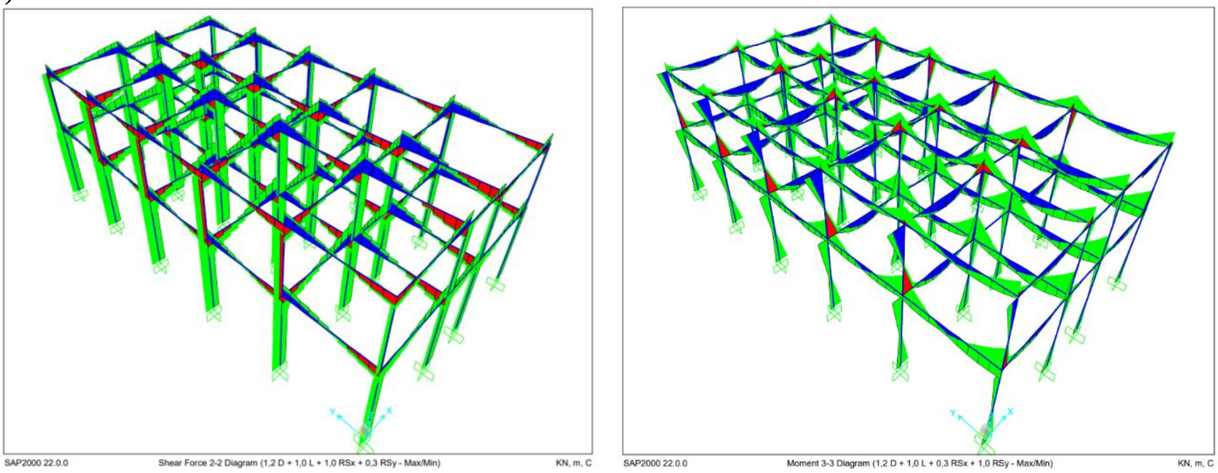
Figure 14. (1) Axial Inside Force (Nu), Nu = 1.4 D = 279.386 KN; (2) Column Momentary Inside Force (Muk) Muk = 1.2D + 1.0L + 1.0RSx + 0.3RSy = 8.8705 KNm

2) Force In Shear and Force in Moment



(1) (2)

Figure 15. (1) Force in Shear (Vu), Vu=1.2 D+1.0 L+1.0 RSx+0.3 RSy = 43.121 kN; (2) Force in Moment (Mu), Mu = 1.2D + 1.0L + 0.3RSx + 1.0RSy = -48.0199 kNm

4) Force In Plate Moment

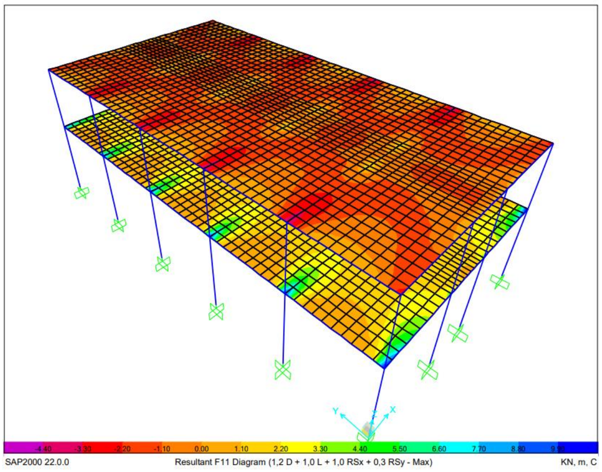


Figure 16. Force in Plate Moment (Mu)

- Min = -4.54 kNm
- Max = 10.698 KNm
- Mu = 1.2D + 1.0L + 1.0RSx + 0.3RSy = -52.4707 kNm

h. Sample 1 Green Concrete Compressive Strength F'c = 19 Mpa Structure Safety

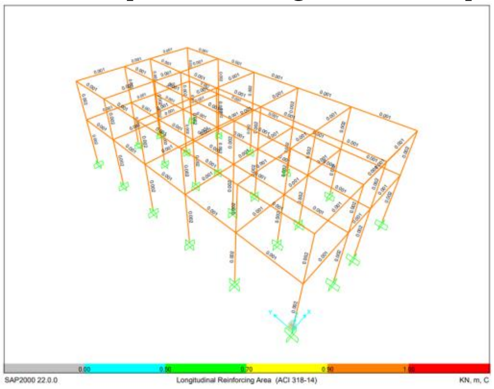
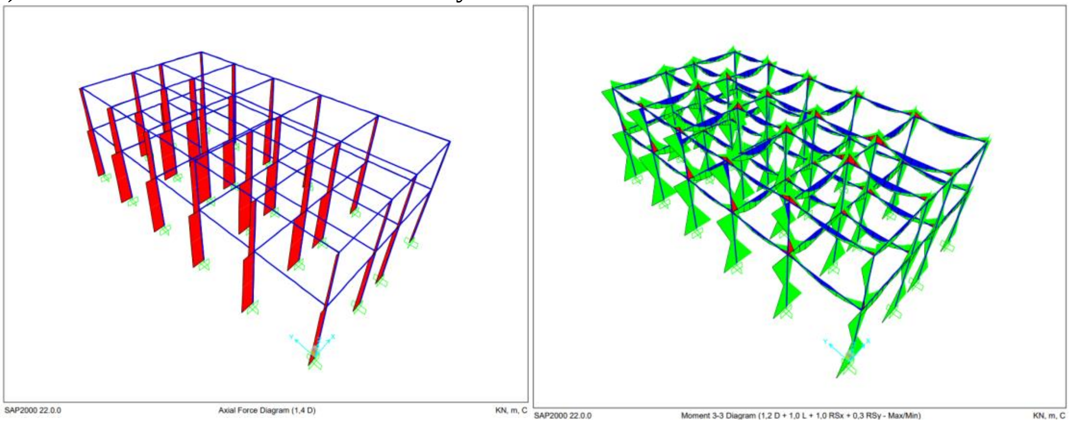


Figure 17. 19 Mpa Structure

The structural analysis results found no structural failure frames, so the portal is feasible using a concrete strength of 19 Mpa.

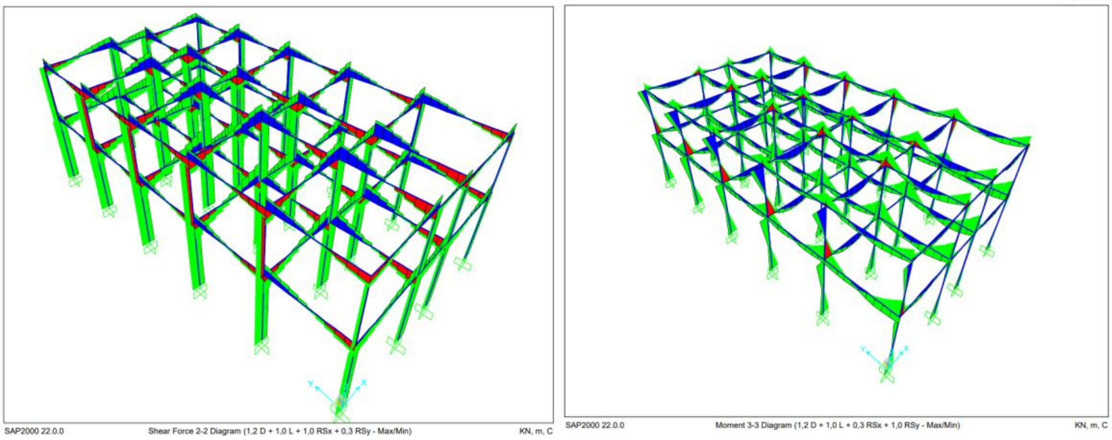
1) Axial and Column Momentary Inside Force



(1) (2)

Figure 18. (1) Axial Inside Force Nu = 1.4 D = 279.386 KN; (2) Column Momentary Inside Force Muk = 1.2D + 1.0L + 1.0RSx + 0.3Rsy = 8.8705 KNm

2) Drawing In Shear



(1) (2)

Figure 19. (1) Force In Shear Vu = 1.2D +1.0L + 1.0RSx + 0.3Rsy = 43.121 kN; (2) Force In Moment (Mu) Mu = 1.2D + 1.0L + 0.3RSx + 1.0Rsy = -48.0204 kNm

4) Force In Plate Moment

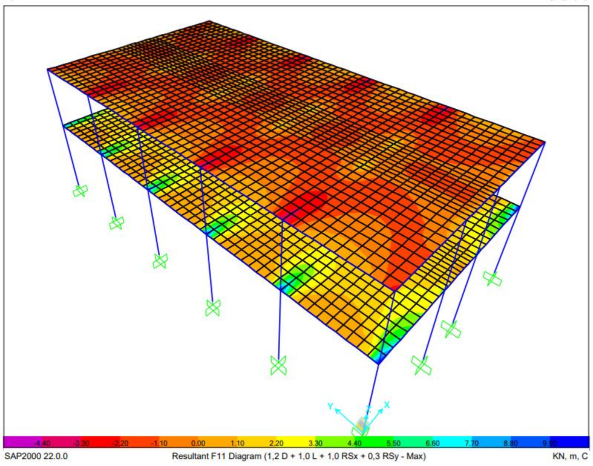


Figure 20. Force in Plate Moment

Airman: Jurnal Teknik dan Keselamatan Transportai
Volume 6 Nomor 2 Desember 2023 | halaman 61-77
DOI: http//doi.org/10.46509/ajtk.v6i2.417

- Max = -4.539 kNm
- Min = 10.699 KNm
- Mu = 1.2D + 1.0L + 1.0RSx + 0.3Rsy =
 -52.4711 kNm

i. Green concrete compressive strength F'c = 17 Mpa Structure Safety

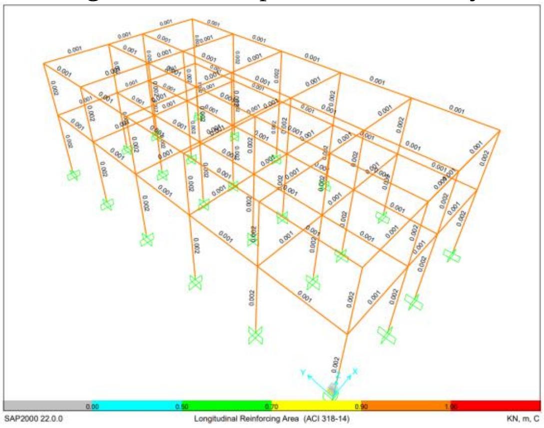
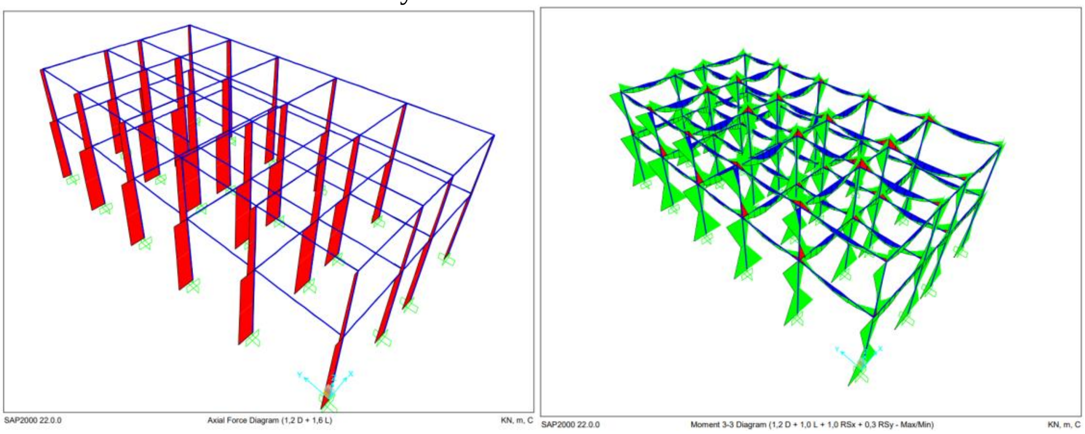


Figure 21. 17 MPa

From the structural analysis results, no frame was found to have a structural failure, so the portal is feasible using a concrete strength of 17 Mpa.

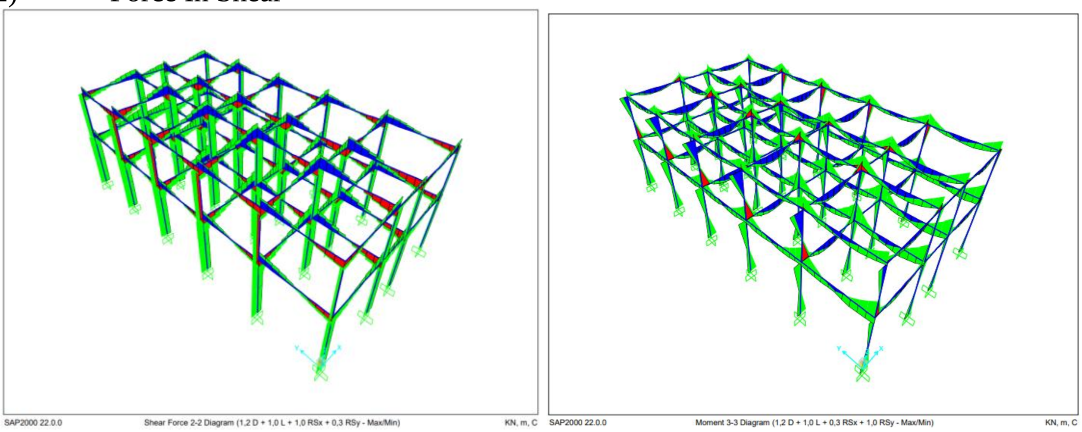
1) Axial and Column Momentary Inside Force



(1) (2)

Figure 22. (1) Axial Inside Force Nu = 1.4D = 279.389 KN; (2) Column Momentary Inside Force (Muk) Muk = 1.2D + 1.0L + 1.0RSx + 0.3Rsy = 8.8705 KN

2) Force In Shear



(1) (2)

Figure 23. (1) Force In Shear (Vu) Vu = 1.2VD + 1.0VL + 1.0VRSx + 0.3VRSy = 43.121 kN; (2) Force In Moment Mu = 1.2D + 1.0L + 0.3RSx + 1.0Rsy = -48.0215 kNm

4) Force In Plate

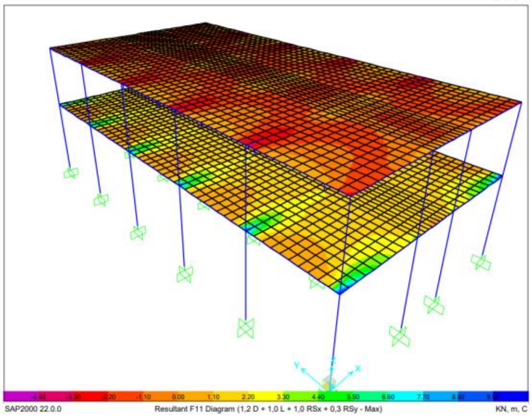


Figure 36: Force In Plate Moment

- Min = -4.538 kNm
- Max = 10.701 KNm

Mu = 1.2MD + 1.0ML + 1.0MRSx + 0.3 MRSy = -52.4721 kNm

From the above analysis, it is concluded that 20 Mpa concrete can show an excellent capacity to resist axial forces. Then it appears strong in resisting column moment, but less as strong as 19 Mpa concrete. After that, it can resist shear forces and is susceptible to significant negative moments. In addition, 20 Mpa concrete has a lower resistance to plate moments than other concretes. The 19 Mpa concrete exhibits a good capacity to resist axial forces similar to the 20 Mpa concrete. This concrete has a column almost equivalent to the 20 Mpa concrete and has good resistance to shear forces. Furthermore, it has a slightly higher negative moment than 20 Mpa concrete. In addition, the plate moment of this concrete is equivalent to 20 Mpa concrete. Then, the 17 Mpa concrete shows good capacity to resist axial forces, similar to 20 Mpa and 19 Mpa concrete. This concrete has the highest column compared to other concretes and has good resistance to shear forces. It has the highest negative moment compared to other concretes. The 17 Mpa concrete has a slightly lower plate moment than the 20 Mpa and 19 Mpa concrete.

From the structural check analysis, the frame safety design is safe in the appropriate category and can withstand the existing loads for the structure. To compare the concrete strength, F'c 20 Mpa, F'c 19 Mpa, and F'c 17 Mpa are shown in Tables 2 and 3.

Table 2. Maximum positive value of loading to the inner force portal structure

Concrete Strength (F'C) MPa	Axial Force (KN)	Shear Force (KNm)	Moment (KNm)
20 Mpa	9,863	43,168	52,5009
19 Mpa	9,864	43,168	52,5014
17 Mpa	9,866	43,168	52,5024

(Data processed, 2023)

Table 3. Maximum negative value of loading to portal structure inner force

Concrete Strength (F'C) Mpa	Axial Force (KN)	Shear Force (KNm)	Moment (KNm)
20 Mpa	-279,386	-43,121	-52,4707
19 Mpa	-279,386	-43,121	-52,4711
17 Mpa	-279,386	-43,121	-52,4721

(Data processed, 2023)

It is concluded from the data that concrete 17 Mpa, 19 Mpa, and 20 Mpa with a safe structure from the analysis of SAP 2000 with all concrete frames passed the stress/capacity check or designed does not occur structural failure with these three concrete strengths. Hence, it is safe in its safety analysis. From the simulated results, the three samples' recommended concrete compressive strength F'c is 19 Mpa and 20 Mpa, respectively. However, 17 Mpa can still be categorized as a safe structure because the mechanical characteristics of concrete are determined not only by compressive strength alone but also by flexural strength, shear strength, modulus of elasticity, and other physical properties.

CONCLUSION

Inorganic waste is a residual substance that can be recycled into valuable products, such as aggregate replacement media for building materials. Several tests proved that the quality of aggregate from inorganic waste as a mixture of building materials meets the criteria like sand and gravel. Green concrete is made from inorganic waste, such as plastic, and uses burned and finely ground fabrics like sand. In experimental testing, green concrete is analyzed through the SAP 2000 V22 application as testing parameters on a superficial level building when applied later. The data obtained in the study shows that all concrete samples have almost the same maximum axial load, indicating that the axial force is mainly influenced by the load applied to the structure, not by the compressive strength of the concrete itself. Furthermore, all concrete samples had the same maximum shear load of 43.168 kN/m. This indicates that at the given load level, all types of concrete have a similar ability to resist shear forces. In addition, all concrete samples had almost the exact maximum bending moment. This may indicate that the maximum moment is also more influenced by the geometry and load on the structure than the compressive strength of the concrete. The higher the moment value the concrete can withstand, the better the concrete is at resisting flexural loads. The difference between the maximum moment in 17 MPa and 20 MPa concrete is about 0.0015 kN/m.

However, in terms of moment, the value is higher in concrete with lower compressive strength. This may be because other configurations or compositions of the concrete, such as the type of additives used in green concrete, may affect its structural performance. The higher the bending moment that concrete can withstand, the better the ability of the structure to withstand bending loads without cracking or failure. It is important to remember that the mechanical characteristics of concrete are not determined by compressive strength alone. Other factors, such as flexural strength, shear strength, modulus of elasticity, and other physical properties, also need to be considered in the design of safe and efficient structures.

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REFERENCE

Al-Mansour, A., Chow, C. L., Feo, L., Penna, R., & Lau, D. (2019). Green concrete: By-products utilization and advanced approaches. *Sustainability (Switzerland)*, *11*(19), 1–30. https://doi.org/10.3390/su11195145

Annajma Junia, P., & Body, R. (2023). Studi Eksperimental Pemanfaatan Limbah Keramik Sebagai Bahan Pengganti Agregat Halus Terhadap Kuat Tekan Beton. *Jurnal Applied Science in Civil Engineering*, *4*(2), 2023.

BADAN STANDARDISASI NASIONAL. PENETAPAN STANDAR NASIONAL INDONESIA 1727:2020 BEBAN DESAIN MINIMUM DAN KRITERIA TERKAIT UNTUK BANGUNAN GEDUNG DAN STRUKTUR LAIN SEBAGAI REVISI DARl STANDAR NASIONAL INDONESIA 1727:2013 BEBAN MINIMUM UNTUK PERANCANGAN BANGUNAN GEDUNG DAN STRUKTUR LAIN. , Badan Standarisasi Nasional 1727:2020 § (2020).

Bambang Agus, & Salim Arif. (2018). Kriteria Dasar Perencanaan Struktur Bangunan Tahan Gempa. *Jurnal*

Teknik Sipil, *11*, 59–72. Retrieved from file:///C:/Users/user/Downloads/787-2466-1-PB.pdf

Darmawan, R. R., Susanti, E., & Fitriyah, D. K. (2021). Studi Komparasi Parameter Respons Spectrum Gempa SNI 1726-2012 Terhadap SNI 1726-2019 Dengan Studi Kasus Gedung C STIE PERBANAS. *Prosiding Seminar Teknologi Perencanaan, Perancangan, Lingkungan Dan Infrastruktur*, 139–145. Retrieved from https://ejurnal.itats.ac.id/stepplan/article/view/1556

Desy, R., & Nova, A. (2018). Penyuluhan Pengelolaan Kebersihan dan Kesehatan Lingkungan Masyarakat Perumnas Payabujuk Seulemak Kec.Langsa Baro Kota Langsa. *Jurnal Olahraga Rekreasi Samudra (JORS)*, *1*(2), 79–85.

Fistcar, W. A. (2021). Study Perilaku Bantalan Beton Untuk Lebar Sepur 1067 mm dengan Variasi Nilai Track Quality Index (TQI). *Jurnal Perkeretaapian Indonesia*, *5*(1), 36–47.

Ghifari, F. R. (2020). Analisis Struktur Gedung Beton Dengan Sistem Pracetak pada Gedung Rusun Joho. *MoDuluS: Media Komunikasi Dunia Ilmu Sipil*, *2*(1), 11. https://doi.org/10.32585/modulus.v2i1.1485

Hasibuan, S. A. R. S., Fadhillah Azmi, & Yuan Anisa. (2022). STUDI PERBANDINGAN ANALISIS STRUKTUR BALOK MENGGUNAKAN APLIKASI BERBASIS ANDROID dan SAP2000. *Jurnal Gradasi Teknik Sipil*, *6*(1), 23–33. https://doi.org/10.31961/gradasi.v6i1.1337

Mahendra, R. S., Meilawati, K., & Wasito, B. (2022). ANALISIS KERUSAKAN SLOOF PADA GEDUNG OPERASIONAL DI BANDAR UDARA KALIMARAU BERAU. *Prosiding SNITP (Seminar Nasional Inovasi Teknologi Penerbangan)*, *6*(1).

Mandasari, F., & Fatra. (2019). Perencanaan Gedung Parkir Mobil Terminal Domestik Di Bandar Udara I Gusti Ngurah Rai Bali. *Langit Biru: Jurnal Ilmiah …*, *12*(2), 1–10. Retrieved from http://journal.ppicurug.ac.id/index.php/jurnal-ilmiah-aviasi/article/view/155

Martayase, W. (2022). Analisis Struktur Bangunan Gedung Asrama 3 Lantai Jati Agung Lampung Selatan dengan Menggunakan Aplikasi SAP 2000. *Jurnal Ilmu Teknik*, Vol. 2, pp. 1–10. Retrieved from http://ilmuteknik.org/index.php/ilmuteknik/article/view/82%0Ahttp://ilmuteknik.org/index.php/ilmuteknik/article/download/82/82

Masril, M., & Rizaldo, J. (2021). Analisis Pengaruh Penambahan Agregat Limbah Plastik (Polyethylene Terephathalate) Terhadap Kuat Tekan Beton. *Ensiklopedia of Journal*, *3*(3), 243–252. https://doi.org/10.33559/eoj.v3i3.771

Mukrimaa, S. S., Nurdyansyah, Fahyuni, E. F., YULIA CITRA, A., Schulz, N. D., غسان ,د., … Harmianto, S. (2016). RANGKA PORTAL (FRAME) 2 DIMENSI ANALISIS STATIK. *Jurnal Penelitian Pendidikan Guru Sekolah Dasar*, *6*(August), 128.

Pangestu, R. S. (2022). *Perancangan Struktur Beton Bertulang Gedung Kantor 3 Lantai Dengan Sistem Rangka*.

Putra, J. (2023). Perancangan Struktur atas Gedung 3 Lantai Tahan Gempa dengan Menggunakan Sistem Rangka Pemikul Momen Khusus (SRPMK) pada Gedung Bank Rakyat Indonesia Saumlaki, Maluku. *ISMETEK*, *15*(2).

Putri, A. P., & Tobing, A. K. (2019). Analisis Kuat Tekan Beton Menggunakan Subtitusi Bahan Ramah Lingkungan. *Jurnal Kajian Teknik Sipil*, *3*(2), 105–109. https://doi.org/10.52447/jkts.v3i2.1353

Rakyat, K. P. U. dan P. (2022). Desain Spektra Indonesia. Retrieved October 19, 2023, from PuSGeN website: http://rsa.ciptakarya.pu.go.id/2021

Risnawati Panca Sakti, Ulfa Sulaeman, & Abd. Gafur. (2021). Peran Mallsampah dalam Efektivitas Pengelolaan Sampah (Studi Kasus di PT. Mallsampah Indonesia). *Window of Public Health Journal*, *2*(4), 621–635. https://doi.org/10.33096/woph.v2i4.217

SARAH, S. (2022). *PERBANDINGAN NILAI DISPLACEMENT ANTARA DENAH DASAR BENTUK LINGKARAN DAN SEGIEMPAT PADA BANGUNAN BERTINGKAT TINGGI*.

Setiawan, A. A. (2017). Pemanfaatan Limbah Spanduk Plastik Sebagai Bahan Tambah Dalam Campuran Beton. *Prosiding Seminar Nasional Dan Gelar Produk Universitas Muhammadyah Malang*, 184–189.

Sila, A. A., Jurusan, M., Sipil, T., Sipil, F. T., Papua, U. Y., Jurusan, D., … Beton, S. (2023). Perbandingan Struktur Beton Bertulang Dengan Baja Pada Gedung Asrama Barak Bujang Polresta Jayapura 3. *Prosiding Seminar Nasional Teknik Sipil*, *1*(1), 169–179.

SNI 1726. (2019). Tata Cara Perencanaan Ketahanan Gempa Untuk Struktur Bangunan Gedung dan Non Gedung. *Badan Standardisasi Nasional Indonesia*, *1726*(8), 254.

SNI, 1727. (2020). Beban desain minimum dan Kriteria terkait untuk bangunan gedung dan struktur lain. *Badan Standarisasi Nasional 1727:2020*, (8), 1–336. BSN.

Susanto, A., Putranto, D., Hartatadi, H., Luswita, L., Parina, M., Fajri, R., … Amelinda, Y. S. (2020). Pemberdayaan Masyarakat Melalui Pengelolaan Sampah Dalam Mengurangi Sampah Botol Plastik Kampung Nelayan Kelurahan Tanjung Ketapang. *Abdi: Jurnal Pengabdian Dan Pemberdayaan Masyarakat*, *2*(2), 94–102. https://doi.org/10.24036/abdi.v2i2.49

Zega, B. C., Dani, H., Triarso, A., & Zulfikar, A. R. (2022). Pelatihan Analisis Pemodelan Struktur Bangunan dengan Menggunakan Software SAP2000 kepada Guru dan Siswa pada SMK Teknik Bangunan. *Seminar Nasional Pengabdian Kepada Masyarakat 2021*, *1*(1), 42–48. https://doi.org/10.33086/snpm.v1i1.775