Journal of Multidisciplinary Engineering Science Studies (JMESS)
ISSN: 2458-925X
Vol. 8 Issue 10, October - 2022

Evaluation of Loading Capacity Diploma IV Study Program Building Polytechnic State Of Samarinda, East Kalimantan

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***Abstract*— The Diploma IV study program (D4) building of the Samarinda State Polytechnic, East Kalimantan is a lecture building where solar panels will be installed on the top floor so that it requires an evaluation of the loading capacity. Evaluation of Loading Capacity Building Diploma IV study program Samarinda State Polytechnic, East Kalimantan, aims to determine the load capacity that can still be supported by the building. Evaluating the stages carried out include modeling the existing building on the SAP 2000 v.14 application, checking each element of the existing load structure, analyzing the flexural capacity, shear force, normal force on columns and beams, and analyzing the foundation safety. Next, the load is added gradually by 25 tons for each main column. Based on the calculation of safety checks on the upper and lower structures, the largest dead load is 1242 kg.m², the live load is 250 kg.m², and the largest wind load is 810 kg. While for structural elements, the largest moment is 141,839 ton.mm, the axial force is 140.416 ton and the shear force is 133.384 ton. It was found that the building can still withstand a load of 13 tons on each main column. The evaluation results found that the existing building structure is still safe.**

***Keywords*—— flexures force, shear force, normal force, building capacity**

I. Introduction

The Diploma IV study program building of the Samarinda State Polytechnic is one of the buildings located in the Samarinda State Polytechnic Complex, Jl. Cipto Mangun Kusumo, Samarinda Seberang District, Samarinda City, East Kalimantan. This building is used for lectures at the Samarinda State Polytechnic, built for teaching and learning purposes for students who have a Diploma IV study program or D4 education level at the Samarinda State Polytechnic.

The Diploma IV study program building of the Samarinda State Polytechnic (Figure 1) was built in 2010 [1], has 4 floors with no roof, where the first floor is the administration room for the marketing management department, the second, third and, fourth floors are used as classrooms to support the teaching and learning process. If the roof is not used as a rooftop, there will be additional loads in the form of solar panels, having different weights and capacities in each type, so that in adding solar panel loads to the building, an evaluation of the existing structure is needed to determine how much load the existing structure can withstand. In the end, solar panels with efficient capacity can be planned to be installed in the building [2].

In analyzing the addition of the maximum load on the building, the dead load entered is based on the condition of the existing structure of the building referring to SNI 03-1727-1989 [3], live load, and wind load. For the calculation of the structure of the building based on SNI 03-2847-2019 [4].

Fig 1. *Project Location Map*

What is considered in the case of increasing the load on a building is how much load the upper and lower structures can withstand. The results of this study indicate the maximum load that the upper and lower structures can withstand. Calculation of the structure using the SAP 2000 application and by using a comparison of manual calculations on the main structural elements by calculating the maximum moment, and the maximum shear force contained in the beams and columns of the building.

II. LITERATURE

The literature review aims to create a theoretical framework and conception as the basis for research problems and to describe some theoretical reasons and formulas that will be used in solving research-related problems quoted from several kinds of literature [5].

A. Basic Definition of Reinforced Concrete Structure

Reinforced concrete is a composite material where steel reinforcement is arranged into the concrete, which serves to withstand the tensile forces on the structure. The two materials work together to form an interaction diagram to resist the forces acting on the elements. The combination of the two materials makes reinforced concrete have very strong properties against compression and tensile forces.

According to (Asroni, 2010) [6] simply, concrete is formed by hardening a mixture of cement, water, fine sand, and coarse aggregate (crushed stone or gravel). To improve the quality of concrete, other ingredients (mixtures) are added. Concrete has a high compression resistance, but very low tensile strength.

The combination of the two materials of concrete and reinforcing steel makes reinforced concrete has strength against compression forces and strength against tensile forces. The weakness of the concrete will be the tensile force borne by the steel reinforcement, on the contrary, the concrete fills the steel reinforcement to avoid the buckling factor. Reinforced concrete has advantages such as resistance to weather and fire.

B. Inner Force

Force is the force that acts in the structure or the force that propagates from the charge to the reaction of the placement. The internal forces resulting from the structural analysis of the SAP 2000 [7] program include:

1. Normal Force / Axial Force (N plane) is an internal force that acts perpendicular to the cross-section or parallel to the axis of the rod.
2. Shear Force (D plane) is a force that acts parallel to the cross-section or perpendicular to the axis line.
3. Moment (M plane) is the internal force that resists bending about the axis of the rod.

C. Reinforced Concrete Design Requirements

Quality of Concrete, a concrete structure is said to be safe if it is known in advance the working loads and the dimensions required so that the quality of the concrete is obtained which is marked by the magnitude of the compression strength of the concrete.

Concrete has high compression strength but low tensile strength, to compensate for the lack of concrete, steel reinforcement which has high tensile strength and low compression strength is used. The quality of steel in Indonesia is divided into 2 qualities, namely the quality of soft steel (plain reinforcing steel) and the quality of hard steel (threaded reinforcing steel).

D. Load Theory

According to SNI 03-1727-1989 [3] Article 1.0, the loads acting on the structural part of the building include:

1. Dead Load is the weight of all fixed parts of a building, including all additional elements, finishes, machinery, and equipment that are an integral part of the building.
2. Live loads are all loads that occur as a result of the occupancy or use of a building, and it includes loads on the floor originating from movable goods, machinery, and equipment that are not an integral part of the building can be replaced. During the life of the building, resulting in changes in the loading of the floors and roofs.
3. Wind load is all loads acting on a building or part of a building caused by differences in air pressure. The blowing pressure should be taken as 25 kg/m². Blow pressure at sea and the seaside as far as 5 km from the coast must be taken at a minimum of 40 kg/m².

E. Strength Needed and Strength Plan

A structure must fulfill requirements for safety and suitability for various existing combinations, so that for each load factor calculation, it has its equation by SNI 2847-2019 [3] article 9.2. The following is the load combination equation:

The required strength U to withstand dead loads D must be at least equal to:

$$U = 1{,}4\ D \quad (1)$$

Strong need U to withstand dead load D, live load L, and also roof load A or rain load R, must be at least equal to:

$$U = 1{,}2\ D + 1{,}6\ L + 0{,}5\ (A \text{ or } R) \quad (2)$$

If the structure's resistance to wind loads W must be taken into account in the design, the effects of the following combinations of D, L, and W loads must be reviewed to determine the greatest value of U, i.e.

$$U = 1{,}2\ D + 1{,}0\ L \pm 1{,}6\ W + 0{,}5\ (A \text{ or } R) \quad (3)$$

The load combination must also take into account the full and empty live load possibilities L to obtain the most dangerous conditions, i.e.

$$U = 0{,}9\ D \pm 1{,}6\ W \quad (4)$$

According to SNI 03-2847-2019 [3] ARTICLE 11.3, the design strength of a structural compound, its connection with other structural members, and its cross-section concerning bending behavior, normal load, shear, and torque must be taken as the result of nominal strength, which is calculated based on the provisions and assumptions of the procedure, with a strength reduction factor as follows :

1. Bending, no axial load = 0,80
2. Axial tensile and axial tension with bending = 0,80

3. Axial compression and axial compression with bending = 0,65
4. Shear dan Torque = 0,75.

F. Restrain

The restraint is a place for laying or supporting the construction in transmitting the forces acting on the foundation [8]. There are two types of building supports, namely:

1. If the restraint can prevent the structure from rotating and is very rigid relative to the torsional moment, then the structure is said to be fully clamped.
2. If the edge beam is not strong enough to prevent rotation at all, then the structure is partially squashed (squeezed elasticity).

G. Structural Component Calculation

i. Floor Plate

Plates are divided into two types:

- ✓ One-way slab (one-way slab), which is a plate that is held in one direction only or on two sides of the plate.
- ✓ Two-way slab (two-way slab), which is a plate that is supported by a beam in both directions or all four sides.

If viewed from the comparison of the long side to the short side of the ≤ 3 plates, the plate must be analyzed as a two-way plate. As a minimum thickness limit, the plate is reviewed based on the maximum deflection limit that occurs according to the quality of the steel used and the structural component.

ii. Beam

A beam is a member of a structure that resists axial bending loads. Calculation of reinforcement in beams refers to the condition of the structure with flexural loads only [9], [10]. Diagram of a beam if it withstands flexural loads then the stress-strain behavior that occurs can be described as follows:

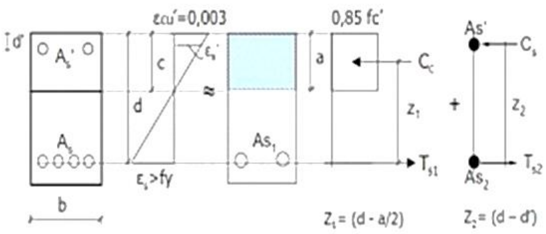

Fig 2. *Beam stress strain diagram*

$Cc = 0{,}85 \cdot f'c \cdot a \cdot b$ (6)

$Ts = As \cdot fy$ (7)

The Whitney stress distribution plane (a) can be determined using the equilibrium principle Cc = Ts, by assuming that the reinforcement reaches the yield point before the crushing of the concrete, then we get:

$$a = \frac{As \times fy}{0{,}85 \times fc' \times b} \quad (8)$$

iii. Column

The column is a part of the structure that resists the axial compression load and the moment where the two loads work simultaneously. The placement of reinforcement in the column is reviewed on the side of the maximum load buckling direction and the reinforcement is installed symmetrically, which means that the area of compression reinforcement is equal to the area of tensile reinforcement.

Calculation of reinforcement in the column refers to the concept of balance of forces due to Pu and Mu forces, as shown in the stress-strain diagram.

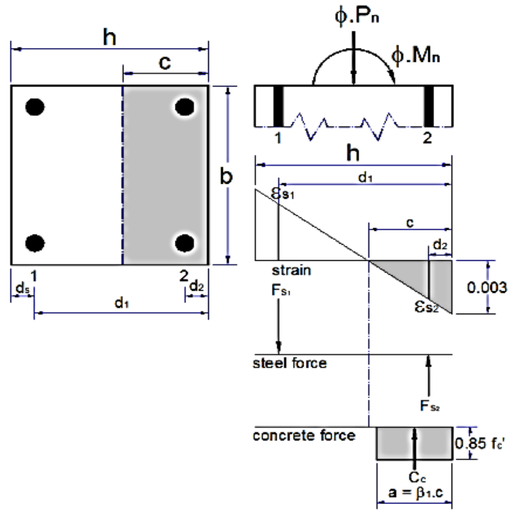

Fig 3. *Column Stress Strain Diagram*

$Mu = Ø \cdot [Ts \cdot (d - c) + Cc \cdot (c - ½ \cdot a) + Cs\,(c - d')]$

$Mu = Ø \cdot [AS.fy\,(d - c) + 0{,}85 \cdot f'c \cdot a \cdot b \cdot (c - ½ \cdot a) + As' \cdot fy\,(c - d')]$ (9)

iv. Shear Reinforcement

Shear stress in structural components can be overcome by the installation of shear reinforcement. The function of shear reinforcement is:

1. Withstand Partially Shearing Force on Cracked Parts.
2. Prevents the diagonal crack from spreading so that it does not continue to the compression part of the concrete
3. Gives a certain strength to the release of concrete, because generally, the stirrups bind the longitudinal reinforcement to form a more massive concrete.

The calculation of shear reinforcement is obtained as follows:

$As = 2(1/4 \times \pi \times D^2)$ (10)

$$Vs = \frac{As \times fy \times d}{s} \quad (11)$$

v. Foundation

The foundation is part of a sub-structure system that supports its weight and all the force loads from the superstructure are then transmitted to the soil and rock layers below it. The load from the column acting on the foundation must be spread over a large enough surface area so that the soil can carry the load safely. Based on the depth elevation, foundations can be classified into two groups, namely shallow foundations, and deep foundations.

III. RESEARCH METHODOLOGY

A. *Research Location*

The location of the project taken for research is at the Samarinda State Polytechnic Campus in Diploma study program 4 Building located on Jalan Jl. Cipto Mangun Kusumo, Sungai Keledang, Kec. Samarinda Seberang, Samarinda City, East Kalimantan 75242.

B. *Drawing Data*

The data was obtained in the form of data in the form of working drawings and also construction data contained in the Contract Documents As-Built Drawings of the Building [1]. The working drawing data include the following:

1. Building Plans
2. Building View Image
3. Building Pieces Fig
4. Partition Plan Drawing
5. Foundation Plan Drawing
6. Foundation Details
7. Column Plan
8. Sloof Block Plan
9. Beam plan 2nd floor.
10. Beam plan 3rd and 4th floor
11. Beam plan roof floor
12. Roof Ring balk Plan

C. *Data Collection*

Data is obtained through 2 methods, namely by direct testing in the field and data contained in contract documents. The data obtained from the test results were carried out by conducting a hammer test (non-destructive test), the concrete compression strength value was 283 kg/cm². Then from the data obtained from the contract documents, the concrete quality is 250 kg/cm². So that the quality is taken in the contract document, then for the steel quality, the quality is used in the contract document, namely with fy 390 MPa and 240 MPa.

D. *Stages of Research Implementation*

The following steps involved in completing this research are:

1) Preparation Phase
2) Data Collection Phase
3) Structure Modeling
4) Load Capacity Evaluation
5) Results and Discussion
6) Conclusion

E. *Flowchart of Research Implementation*

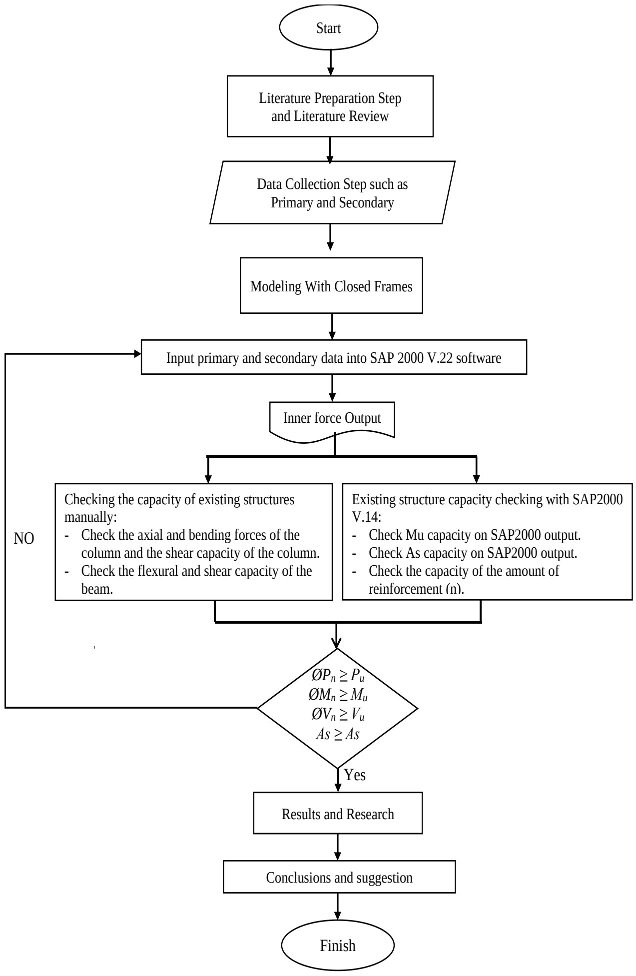

Fig 4. *Flowchart*

IV. RESULT AND RESEARCH

A. *Dimensions of Structural Elements*

a) Concrete Quality : f'c 25 MPa

b) Steel quality : fy 390 dan fy 240 MPa

c) Sloof Dimensions : BS 25 cm / 40 cm
: BSP 15 cm / 20 cm
: BST 25 cm / 30 cm

d) Beam dimensions : B1 30 cm / 40 cm
: B2 30 cm / 40 cm
: B3 30 cm / 40 cm
: B4 30 cm / 50 cm
: B5 20 cm / 30 cm

e) Column Dimension : K1 50 cm / 50 cm
: K2 20 cm / 20 cm

f) Floor Plate Thickness : 12 cm

g) Thickness of Dak Plate : 10 cm

B. Loads

TABLE I. VALUE OF LOADING ON EACH FLOOR

Descrip-tion	Floor	Roof-top	Concrete wall	partition wall
	(kg/m²)			
1st Floor	-	-	1292	50
2nd Floor	87.2	-	1042	40
3rd Floor	87.2	-	1042	40
4th Floor	87.2	-	1042	40
5th Floor	-	21.1	-	-

Dead load due to the self-weight of reinforced concrete, in the loading system is not inputted, it is enough to provide a load patent value = 1 in the SAP 2000 v.14 system, the self-weight of reinforced concrete is automatically inputted into the dead load from its weight [11], [12].

C. Calculation of Beam Structural Components

The following is the calculation of one of the beam structures on the 2nd floor with a size of 30 cm x 40 cm (B1) with the value of the support moment, field moment, and shear force obtained from SAP 2000 v. 14.

Is known

Compression Streng Concrete (f'c) : 25 MPa

Yield stress of flexural reinforcement (fy) : 390 MPa

Yield stress of shear reinforcement (fys) : 240 MPa

Beam width : 300 mm

Beam Height : 400 mm

Concrete Blanket Thickness : 30 mm

Support Mounted Flexural Reinforcement : 8 D19

Field Mounted Flexural Reinforcement : 6 D19

Pedestal Mounted Shear Reinforcement φ10 - 100

Field Mounted Shear Reinforcement φ10 - 150

1) Checking the flexural reinforcement at the pedestal:

a) SAP 2000 v.14 calculation result output:.

$M^{(-)}$ = 127737119 Nmm

B : 300 mm

H : 400 mm

Ø : 0,80

b) Checking the flexural reinforcement at the supports based on the as-built drawing :

As : ¼ x 3.14 x d² x n

: ¼ x 3.14 x 19² x 8

: 2.267,08 mm

ρ : $\frac{As}{b \ x \ h}$

ρ : $\frac{2267.08}{300 \ x \ 400}$

: 0,018892

Φ : 0,8

a : $\frac{As \ x \ fy}{0.85 \ x \ f'c \ x \ b}$

: $\frac{2.267,08 \ x \ 390}{0,85 \ x \ 20,75 \ x \ 300}$

: 167,0987 mm

d : 400 – (30 + 10 + (0,5 X 19))

: 350.5 mm

Actual M without Reduction factor:

= As x fy x (d – (a/2))

= 1.700,31 x 390 x (350.5 – (125,3241 /2))

= 236027390.03 Nmm

Actual M with reduction factor :

= 0,8 x As x fy x (d – (a/2))

= 0,8 x 2.267,08 x 390 x 350.5 – (167,0987/2))

= 188821912.03 Nmm

Requirement : M Actual > $M^{(-)}$ SAP 2000 v. 14

M actual = 236027390.03 Nmm

$M^{(-)}$ Sap = 127737119 Nmm

236027390.03 Nmm > 127737119 Nm…**OK**

2) Checking the Flexural Reinforcement on the Field:

a) Calculation result output:.

M(+) = 84177069.86 Nmm

b : 300 mm

h : 400 mm

Ø : 0,80

b) Checking the flexural reinforcement at the supports based on the as-built drawing :

As : ¼ x 3.14 x d² x n

: ¼ x 3.14 x 19² x 6

: 1.700,31 mm

ρ : $\frac{As}{b \ x \ h}$

: $\frac{1.700,31}{300 \ x \ 400}$

: 0,014169

Φ : 0,8

a : $\frac{As \ x \ fy}{0.85 \ x \ f'c \ x \ b}$

: $\frac{1.700,31 \: x \: 390}{0,85 \: x \: 20,75 \: x \: 300}$

: 125,3241 mm

d : 400 – (30 + 10 + (0,5 X 19))

: 350.5 mm

Calculation of the actual moment of the field :

Actual M without Reduction factor :

= As x fy x (d – (a/2))

= 2.267,08 x 390 x (350.5 – (167,0987/2))

= 190871375.76 Nmm

Actual M with reduction factor :

= 0,8 x As x fy x (d – (a/2))

= 0,8 x 2.267,08 x 390 x 350.5 – (167,0987/2))

= 152697100.60 Nmm

Requirement : M Actual > $M^{(-)}$ SAP

M actual = 1908871375.76 Nmm

$M^{(+)}$ Sap = 84177069.86 Nmm

1908871375.76 Nmm > 84177069.86 Nmm...**OK**

3) Shear Reinforcement Check :

c) SAP 2000 v.14 calculation result output:.

Vu = 96784.94 N

fy = 390 MPa

d) Checking the flexural reinforcement at the supports based on the as-built drawing:.

Av : (¼ x 3,14 x d²) x 2

Av : (¼ x 3,14 x 10²) x 2

Av : 157 mm

Vn Actual: $\frac{Av \: x \: fy \: x \: d}{s}$

Vn Actual: $\frac{157 \: x \: 240 \: x \: 350,5}{(100)}$

Vn Actual : 1507200 N

Requirement : Vs Actual > Vs SAP

In actual = 132068,40 N

Vu Sap = 96784.94 N

132068,40 N > 96784.94 N .... **OK**

D. Calculation of Column Structure Compound

The following is the calculation of one column structure with a size of 50 cm x 50 cm (K1) with the value of the moment of support, shear force, and axial obtained from SAP 2000 v. 14.

As known

Compression Streng Concrete (f'c) : 25 MPa

Yield stress of flexural reinforcing (fy) : 390 MPa

Yield stress of shear reinforcement (fys) :240 MPa

beam width : 500 mm

Beam Height : 500 mm

Concrete Blanket Thickness : 30 mm

Mounted Flexural Reinforcement : 12 D 22

Installed Shear Reinforcement : Ø10 - 150

1) Longitudinal reinforcement check:

a) Column eccentricity check:.

e = $\frac{Mu}{Pu}$ emin = 0,1 x h

e = $\frac{123666818}{1604159,71}$ emin= 0,1 x 500

e = 77,091 mm emin = 50 mm

$e < e_{min}$

77,091 mm > 50 mm (column not with concentrated axial load)

b) Location of the neutral line in balance conditions:.

d = h – ½ . Main Reinforcement – shear reinforcement – concrete covers

= 500 – ½ . 22 – 10 – 30

= 449 mm

d' = h -d

= 500 – 449

= 51 mm

Cb = $\frac{600}{600+fy}$ + d

= $\frac{600}{600+390}$ + 449

= 272, 12 mm

Cb = $\frac{0,003}{0,003+\frac{fy}{Es}}$ .d

= $\frac{0,003}{0,003+\frac{390}{200000}}$. 449

= 272,12 mm

ab = β x cb

= 0,85 x 272,12

= 231,302 mm

Finding the value of As reinforcement:

Reinforcement using 12 D 22

As = As'

= n . area of reinforcement used

= n . ¼ π d^2

= 12 . ¼ . 3,14 . 22^2

= 4559,28 mm²

Column collapse type:

Pnb = 0,85 . f'c . ab . b + As . fy – As . fy

= 0,85 . 20,75 . 231,302 . 500 + 4559,28 .390 – 4559,28 . 390

= 98303,35 N

Pn $= \frac{PU}{\varnothing}$

$= \frac{1604159,71}{0,65}$

= 24679398, 015 N

Shown that Pn > Pnb

24579298,015 N > 98303,35 N (Compressive collapse analysis)

Cross-sectional capacity subjected to compression failure:

Pn $= \frac{A's\ .\ fy}{\left(\frac{e}{d-d'}\right)+0,5} + \frac{b\ .\ h\ .\ f'c}{\left(\frac{3.h\ .e}{d^2}\right)+1,18}$

$= \frac{4559,28\ .\ 390}{\left(\frac{77,091}{500-51}\right)+0,5} + \frac{500\ .\ 500\ .\ 390}{\left(\frac{3.500\ .77,091}{449^2}\right)+1,18}$

= 13418737,49 N

Ø Pn > Pu

0,65 . 13418737,49 N > 3746957 N

8722179, 369 N > 3746957 N **Oke…..**

After checking manually, the largest Pu and Mu values were entered into the Sp column auxiliary software to find out the interaction diagram.

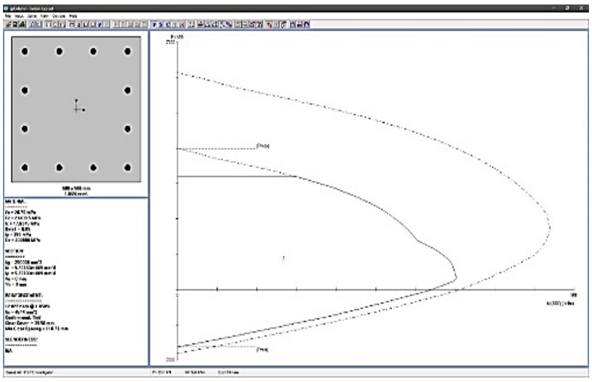

Fig 5. *Interaction Diagram between Pu and Mu*

2) Checking of flexural reinforcement in the column Moment that occurs in the flexural reinforcement :

$M2^{(-)}$ = 123666818 Nmm

Pu = 518833,6 N

From the data obtained and calculated :

B : 500 mm

H : 500 mm

As : ¼ x 3.14 x d² x n

: ¼ x 3.14 x 22² x 12

: 4559,28 mm

Φ : 0,65

β : 0,85

c : $\frac{Pu}{\Phi \text{ x } 0,85 \text{ x } f'c \text{ x } b \text{ x } \beta}$

: $\frac{518833,6}{0,65 \text{ x } 0,85 \text{ x } 20,75 \text{ x } 500 \text{ x } 0,85}$

: 106,485

a : β x c

: 0,85 x 106,485

: 90,5123 mm

d : 500 – 22 – 10 - 30

: 438 mm

d' : h – d

: 500 – 438

: 62 mm

Actual Moment Calculation:

= ϕ . [Ts . (d – c) + Cc. (c – ½ . a) + Cs (c – d')]

= ϕ . [$As.\ fy$ (d − c) + 0,85 . f'c .a. b. (c – ½ . a) + As'. fy (c – d')]

= 0,65 . [4559,28 . 390 (438 – 106,485) + 0,85 . 20,75 . 90,5123 .

500 (106,485 – ½ . 90,5123) + 4559,28 . 390 (106,485 – 62)]

= 0,65 . [589473186,6 + 48873195,38 + 79099632,61]

= 466339956,6 Nmm

Requirement : M Actual > $M2^{(-)}$ SAP

M actual = 466339956,6 Nmm

$M2^{(-)}$ Sap = 123666818 Nmm

466339956,6 Nmm > 123666818 Nmm **….. OK**

3) Shear Reinforcement Check:

Vs = 79861,34 N

From the data obtained :

Av : (¼ x 3,14 x d²) x 2

: (¼ x 3,14 x 10²) x 2

: 157 mm

Vs Actual : $\frac{Av \text{ x } fy \text{ x } d}{s}$

: $\frac{157 \ x \ 240 \ x \ 438}{150}$

: 125600 N

Requirement : Vs Actual > Vs Sap

Vs actual = 125600 N

Vs Sap = 79861,34 N

125600 N > 79861,34 N .... **OK**

E. Graph of Relationship Between As and P to Find Maximum Load.

To determine the largest load that can still be held by the column, a graph of the relation between the axial load and the installed reinforcement will be made using the formula to find the largest load.

TABLE II. RELATION BETWEEN P DAN AS

P	As (mm^2)
0	2499,99
25	2499,99
50	2499,99
75	2499,99
100	2499,99
125	3226,92
150	5765,11
175	8961,24
200	13260,1
225	OS

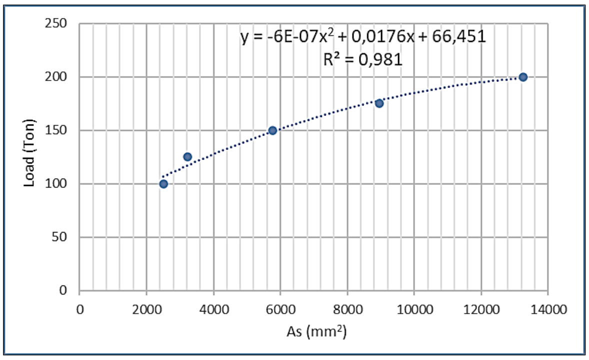

Fig 6. *Graph of Relationship between P and As*

Finding Maximum Load :

From the Graph Get the Formula :

y = -0,00000006 . 13260² + 0,0176 . 13260 + 66,451

y = - 105,49 + 233,37 + 66,451

y = 194,331 Ton

So that the largest load that the column can still withstand in the Diploma study program 4 building of the Samarinda State Polytechnic is 194,331 tons.

F. Foundation Calculation.

The following is the calculation of the Footplate foundation which is the main foundation in the D4 Samarinda State Polytechnic building. In this foundation calculation, the largest axial force on the column is used after the addition of the maximum load.

As known :

Foundation Length (P) : 1500 mm

Foundation Width (L) : 1500 mm

Foundation Thickness (t) : 500 mm

Concrete Foundation Cover : 75 mm

Pu : 3462036,54 N

1) Analyze the thickness of the foundation against the load received :

$q_{u\ net}$: $\frac{Pu}{Lpond}$

: $\frac{3462036,54}{1500 \ x \ 1500}$

: 1,583 N/mm²

d : t – foundation covers

: 500 – 75

: 425 mm

b_o : 4 (500 + 425)

: 3700 mm

for the two-way reaction :

V_{u2} : qunet x large

: l,583 . (1500² - 500²)

: 3166000 N

: 3166 kN

V_c : 0,33 . $\sqrt{f'c}$. bo . d

: 0,33 . $\sqrt{20{,}75}$. 3700 . 425

: 2363815,873 N

: 2363,815873 kN

V_c : $\left(\frac{\alpha s.d}{bo} + 2\right) . \sqrt{f'c} . bo . d/12$

: $\left(\frac{40 \ . \ 425}{3700} + 2\right) . \sqrt{20{,}75} . 3700 . 425/12$

: 6,594 . 4,555 . 3700 . 35,416

: 3936466,509 N

: 3936,466509 kN

Then take V_c equal to 2363,815873 kN

ϕ . V_c = 0,65 x 2363,815873

= 1536,480317 kN

Requirement: . $V_c > V_{u2}$

$\phi . V_c$ = 1536,480317 kN

V_{u2} = 3166 kN

$\phi . V_c < V_{u2}$

1536,480317 kN < 3166 kN…….**NOT OK**

Find the largest load that the foundation can still withstand :

V_{u2} : qunet x large

1536480,317 : qunet x (1500^2 - 500^2)

$q_{u\ net}$: $\frac{1536480{,}317}{(1500^2 - 500^2)}$

$q_{u\ net}$: 0.768 N/mm²

0,768 : $\frac{Pu}{(1500 \times 1500)}$

Pu : 1728000 N

Pu : 1728 kN

Pu : 176,21 Ton

The load that can be endured :

= Maximum foundation load – existing building load

= 176 ton – 163 ton

= 13 ton

Then check again whether an additional load of 13 tons fulfills the maximum strength of the foundation

Pu : 1723845,82

2) Analyze the thickness of the foundation against the load received :

$q_{u\ net}$: $\frac{Pu}{Lpond}$

: $\frac{1723845{,}824}{1500 \times 1500}$

: 0,766 N/mm²

Vu2 : qunet x large

: 0,766 . (1500^2 - 500^2)

: 1532000 N

: 1532 kN

Syarat : ϕ . Vc > Vu2

ϕ . Vc = 1536,480317 kN

Vu2 = 1532 kN

ϕ . Vc > Vu2

1532 kN > 3166 kN…….. **OK**

Thus, the thickness d = 500 mm is sufficient to withstand the two-way action, shearing the punch at an additional load of 13 tons

for one-way action :

$= \frac{L}{2} - \frac{a}{2} - d$

$= \frac{1500}{2} - \frac{500}{2} - 450$

= 750 – 250 – 425

= 75 mm

Vu1 = 0,65 x 1500 x 75

= 73125 N

= 73,125 kN

The nominal shear connection that occurs

Vc = (1/6 . $\sqrt{f'c}$) . bw . d

= (1/6 $\sqrt{20{,}75}$) . 1500 . 425

= 483991,7839 N

= 483,9917839 kN

Actual shear strength

= 0,65 x 483991,7839

= 314594,6595 N

= 314,5946595 kN

Requirement : ϕ . Vc > Vu2

ϕ . Vc = 314,5946595 kN

Vu1 = 73,125 kN……**OK**

Because the value of the actual shear strength is still greater than Vu1 then the thickness d = 500 mm is also sufficient to withstand one-way shear. Then shear reinforcement is not needed.

3) Check for bending moment :

$$Rn = \frac{Mu}{\phi\, b.d^2}$$

$$= \frac{122531654{,}1}{0{,}9 . 1500 . 425^2}$$

= 0,502

$$\rho \text{ need} = \frac{0{,}85 . f'c}{fy} \left[1 - \sqrt{1 - \frac{2Rn}{0{,}85 . f'c}} \right.$$

$$= \frac{0{,}85 . 20{,}75}{390} \left[1 - \sqrt{1 - \frac{2 . 0{,}502}{0{,}85 . 20{,}75}} \right.$$

= 0,04522 . [1 – 0,971]

= 0,0013

As need = ρ . b . d

= 0.013 . 1500 . 425

= 828,75 mm²

As min = 0,0018 x 1500 x 500

= 1350 mm²

On Existing installed D22-150

As = ¼ . 3,14 . 22^2

= 379,94 mm^2

in the field there are 10 pieces then,

As = 379,94 . 10

= 3799,4 mm^2

Requirement: As existing > As nee/min

As existing = 3799,4 mm^2

As min = 1350 mm^2

3799,4 mm^2 > 1350 mm^2**……..OK**

Then the existing flexural or main reinforcement can withstand the bending moment that occurs due to an additional load of 13 tons.

V. CONCLUSION

From the research on the Loading Capacity Evaluation of the Diploma study program 4 State Polytechnic of Samarinda, East Kalimantan, it can be concluded that :

1) The results of the structural analysis in the Diploma study program 4 Building of the Samarinda State Polytechnic, East Kalimantan obtained the moment of support, field moment and shear force that occurred are as follows :

a) Beam :

Code	Toehold Moment (N.mm)	Field moment (N.mm)	Shear forces (N)
B1	-127737119	84177069.86	96784.94
B2	-178096023	141839107.7	1333840.7
B3	-1,332E+09	94125765.46	121935.75
B4	-121250398	9150461.14	77443.18
B5	2815100.73	1760710.47	2773.18
BS	-77963521	40655419.67	65278.23

b) Column :.

K1 (50 cm x 50 cm):
M2 = 113664769 N.mm
M3 = 122531654 N.mm
Shear Force = 79861 N

2) After analyzing the Diploma study program 4 building State Polytechnic Samarinda, East Kalimantan, the loads that can still be supported by the upper and lower structures of the building are as follows :

a) Based on the structure of the building, namely the column in resisting bending and shearing moments, it is 194,331 tons

b) Based on the bearing capacity of the foundation soil, which is 1125 tons

c) Based on the ability of foundation reinforcement to withstand bending and shear moments, which is 13 tons

d) So take a low load of 13 tons

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