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Improvement Studies for Building Capacity at Bali State Poly-technic

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Abstract

Bali State Polytechnic has 6 majors, with 32 study programs. As many prospective students are interested in studying at the Bali State Polytechnic, it is not in line with the addition of classrooms. Until the 2021, PNB ideally needs 214 classrooms, while the number of available rooms is 142 classrooms. Thus PNB in 2021 still has a shortage of 72 learning rooms. In this study, a case study was taken in a Civil Engineering lec-ture building with a study of increasing space capacity through adding floors to existing buildings. The research was conducted by analyzing the strength of the building in terms of structure. The methods used are field studies and data analysis. Field studies are carried out through testing on the strength of existing structures, then from the results of field studies continued by analyzing additional designs. The capacity of the lecture building at the Bali State Polytechnic can be increased because the strength of the existing lecture building structure is able to bear the load due to the addition of space capacity from 2 floors to 3 floors. The maximum area of column reinforcement on the 1st floor (K30/501) is 22.47 cm2 where the ratio of column reinforcement area to its cross-sectional area (ρcolumn) = 1.5% less than 4%, this means that the column is safe in carrying gravity loads and earthquake loads that occur. The dimensions of the existing foundation (150 x 150 cm) obtained the voltage that occurs is 2.759 kg/cm2 exceeding the ground permit voltage (Ϭ') = 1.133 kg/cm2, so the existing foundation is not able to bear the axial force of the 3rd floor lecture building. The combined foundation / column (150 x 13,470 cm) obtained the voltage that occurs is 1,122 kg / cm2 smaller than the ground permit voltage (Ϭ') = 1,133 kg / cm2, so the combined foundation / column can be used to be able to bear the axial force of the 3rd floor lecture building.

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1 Introduction

The number of new student registrations has grown by an average of 15%, so it can be interpreted that PNB is increasingly in demand by high school / vocational graduates as a choice of places to continue their studies. With the increasing interest of graduates to study at PNB, it must be followed by the addi-tion of facilities and infrastructure. The development of student capacity from 2017 was 1,651 people, in 2018 there were 1,786 people, in 2019 there were 1,891, in 2020 there were 2,002 people, in 2021 there were 2,195 people, and in 2022 there were 2,683 people. The Teaching and Learning Process (PBM) will run well and smoothly if supported by adequate facilities and infrastructure and according to industry needs. The availability of adequate facilities and infrastructure supports the sustainable growth of PNB, preparing itself to face major issues that become trends, namely globalization, higher education-industry linkage, economic development and sustainable development issues (Voerman et al., 2014; Pas et al., 2015).

This study was conducted by evaluating the ability of the initial structure including beams, columns and plates due to the addition of levels and periods of the structure. Reinforcement of structural elements carried out with concrete jacketing and several modeling to be used as reinforcement recommendations (Saruni et al., 2017). Evaluation also needs to be carried out on the foundation of the building based on SNI 2847-2019 (Procedure for planning the foundation of the palm) (Antonius & Susilo, 2020). Analysis and evaluation in the structural analy-sis program are modeled with the same dimensions as the existing conditions and will be increased the number of floors with dimensions according to the preliminary design calculation (Subagio & Putra, 2021). Structural analysis was performed using SAP 2000. In previousstudies, structural analysis of building floor additions could use the ETABS v.18.1.1 program so that internal forces in the form of axial, moment and shear forces Rifaldo & Wibowo (2021) were obtained.

2 Methodology

In this research study will raise the addition of room capacity that can be added to the Civil Engineering lecture building at the Bali State Polytechnic. The research conducted was descriptive research with a case study research method on the strength of existing building structures in terms of carrying the load due to increasing space capacity from 2 floors to 3 floors. The project used as the object of research is the Civil Engineering lecture building at the Bali State Polytechnic, Badung Regency. To be able to per-form a good analysis, data is needed that includes information and theory concepts related to the object to be analyzed. The data sources in this study are primary data and secondary data. In this study, which includes primary data are the Existing Drawings of Civil Engineering lecture buildings, Bali State Poly-technic, Existing Concrete Quality Data obtained by conducting a compressive test on existing buildings (Hammer Test), and data on the size of the foundation of the existing lecture building by multiplying and measuring directly. Secondary Data is data obtained from other parties indirectly from research subjects. Secondary data include data on building regulations such as SNI 03-1726-2002, SNI 03-2847-2002, PPIUG 1983 and PMI 1970 from the Public Works Office (Sun et al., 2021; Ellingwood, 2001).

Data collection techniques are carried out by field observation through testing hammer tests, and evalua-tion of foundation size. Briefly The research steps are as follows:

1. The preparatory stage, at this stage collects all information concerning all aspects of the interests of the object of research. The objects of research are planning drawings, Civil Engineering Building Lecture Shop drawing drawings, and SNI regulations for building build-ings.
2. Testing the quality of concrete used in civil engineering lecture buildings with Hammer test testing and checking the size of the foundation used in existing buildings.
3. The stage of making structural models in accordance with shop drawing drawings using the SAP 2000.14.2.2 program, by taking references from SNI 1727-2020, SNI 2847-2019, SNI 1726-2019 and SNI 1729-2020 are building standards. By inputting existing concrete quality materials and loads according to Indonesian national standards in the SAP 2000.14.2.2 program, data will be produced in the form of internal forces so that the results can be used to assess the strength / capacity of civil engineering lecture buildings.
4. At this final stage, we will obtain conclusions from the formulation of the problem above, to provide recommendations in terms of increasing the capacity of lecture buildings at the Bali State Polytechnic.

The test equipment used is the Schmidt Hammer Test. The operation of Schmidt Hammer on concrete is relatively easy to do. However, care must be taken so that the results obtained can be accounted for (Proceq – Operating Instruction Original Schmidt Concrete Test Hammer – Type N and NR) (Sumajouw et al., 2018). Struc-tural analysis using SAP 2000 resulted in differences in the magnitude of forces in rods, these differences were caused by different levels of accuracy (Diana et al., 2020).

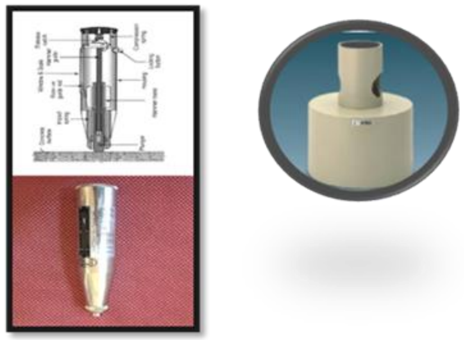


Figure 1. Schmidt Concrete Test Hammer – Type N and NR

The results of the analysis of the influence of muddy, waterlogged, exposed to direct sunlight and pro-tected environmental conditions on existing concrete and reinforcing steel materials are the parameters of the plan to be rebuilt [7]. The use of hammer tests as a comparison of compression under normal conditions is currently widely used [8]. Other regulations used in structural planning are:

1. SNI Indonesian National Standard SNI 1727-2020, Minimum Design Load and Relat-ed Criteria for Buildings and other Structures (National Standardization Agency, 2020).
2. Indonesian National Standard SNI 2847-2019, Procedures for Structural Planning of Concrete for Building (Kuswinardi et al., 2021).
3. Indonesian National Standard SNI 1726-2019, Planning Procedures for Earthquake Resistance for Building and Non-Building Structures (National Standardization Agency, 2019).
4. Indonesian National Standard SNI 1729-2020, Specification for structural steel build-ings (National Standardization Agency, 2020).
5. SNI 03-6197-2000 Procedures for planning building structures for the prevention of fire hazards in houses and buildings (Indonesian National Standard Agency, 2000).

3 Results and Discussions

Concrete Compressive Strength Test Method in Civil Engineering Lecture Building

Non-Destructive Test Inspection method is a method of testing concrete construction by not damaging structural elements or test objects. Destructive Test is a test of concrete construction by damaging structural elements or test objects.

Operation and Use of Schmidt Hammer Test.

The sample taken is 20 points. The results are:

Table 1
Data P-test Hammer Test for Civil Engineering Lecture Building

DATA PENGUJIAN:											
Jenis Data		DATA UJI HAMMER TEST									
Kode Elemen Struktur		Kolom Lt.1, K1-1	Blk. arah X, Bx-1	Blk. arah Y, By-1	Plat lantai, P1	Kolom Lt.1, K1-2	Plat lantai, P2	Blk. arah X, Bx-2	Blk. arah Y, By-2	Plat lantai, P3	Kolom Lt.1, K1-3
Impact Angel (Derajat)		0	0	0	90	0	90	0	0	90	0
IMPACT NUMBER / NO. TITIK TEMBAK	1	43	37	44	44	39	48	37	40	42	36
	2	50	40	36	46	46	46	38	44	48	40
	3	40	36	40	49	40	49	37	34	40	38
	4	40	38	37	50	40	48	36	34	46	36
	5	43	40	40	40	41	49	38	41	46	42
	6	42	40	39	44	42	50	37	42	40	44
	7	44	42	40	46	48	48	34	39	47	36
	8	44	38	44	43	42	48	36	40	46	38
	9	41	33	36	40	43	44	39	38	48	37
	10	46	40	41	48	38	48	38	37	50	42
	11	46	39	42	41	42	48	38	39	44	38
	12	46	38	37	44	45	49	37	35	48	36
	13	44	42	38	46	49	50	37	42	44	34
	14	46	41	38	48	43	44	38	38	45	44
	15	42	36	39	48	48	46	38	38	45	41
	16	38	42	36	48	46	42	37	43	44	38
	17	45	36	44	44	44	48	38	44	43	38
	18	44	40	39	40	45	48	38	44	44	40
	19	42	36	42	44	45	50	38	45	46	39
	20	43	38	40	45	44	50	36	46	45	40

DATA PENGUJIAN:											
Jenis Data		DATA UJI HAMMER TEST									
Kode Elemen Struktur		Ring Balok, Rb-1	Kolom atas, K2-1	Kolom atas, K2-2	Ring Balok, Rb-2	Kolom atas, K2-3	Ring Balok, Rb-3	Blk. arah X, Bx-3	Plat lantai, P4	Plat lantai, P5	Blk. arah Y, By-4
Impact Angel (Derajat)		0	0	0	0	0	0	0	90	90	0
IMPACT NUMBER / NO. TITIK TEMBAK	1	38	40	36	33	36	37	38	52	48	40
	2	38	36	34	36	34	38	36	54	48	42
	3	38	40	40	32	32	41	37	53	50	38
	4	36	38	39	33	35	40	36	44	52	39
	5	42	41	39	33	34	42	36	43	54	40
	6	40	39	36	33	33	43	35	46	50	38
	7	44	40	33	35	33	38	37	41	48	42
	8	43	36	34	36	32	42	37	43	48	42
	9	41	38	37	33	36	41	38	46	44	40
	10	40	39	42	34	33	38	38	40	46	40
	11	40	36	36	33	36	36	39	47	45	38
	12	39	38	35	36	37	33	35	42	45	38
	13	41	37	39	38	35	39	36	42	46	41
	14	42	36	38	36	36	37	37	44	48	40
	15	38	40	38	36	33	41	39	43	48	38
	16	40	36	38	36	32	42	39	44	46	38
	17	39	40	37	35	31	38	35	44	44	38
	18	38	40	38	36	32	41	36	40	46	40
	19	37	36	38	36	35	37	34	46	44	38
	20	38	38	36	35	36	38	36	46	45	39

Based on the above data, further analysis was carried out, the results of the analysis are:

Table 2
Analysis Results D or Ptest Hammer Test Gedung Kuliah Teknik

NO.	ELEMEN STRUKTUR YANG DITEST	Sudut tembak - α (derajat)	Nilai Karakteristik Bacaan Pantulan Alat (R)	Kuat Tekan Beton pada saat ditest (benda uji Kubus)	
				(Mpa)	(Kg/cm^2)
1	Kolom Lt.1, K1-1	0	39.01	40.018	***400.18***
2	Blk. arah X, Bx-1	0	34.60	31.989	***319.89***
3	Blk. arah Y, By-1	0	35.30	33.256	***332.56***
4	Plat lantai, P1	90	39.85	34.439	***344.39***
5	Kolom Lt.1, K1-2	0	38.47	38.719	***387.19***
6	Plat lantai, P2	90	44.03	42.452	***424.52***
7	Blk. arah X, Bx-2	0	35.42	33.400	***334.00***
8	Blk. arah Y, By-2	0	34.24	31.157	***311.57***
9	Plat lantai, P3	90	40.81	36.159	***361.59***
10	Kolom Lt.1, K1-3	0	34.33	31.351	***313.51***
11	Ring Balok, Rb-1	0	36.18	34.523	***345.23***
12	Kolom atas, K2-1	0	35.31	33.266	***332.66***
13	Kolom atas, K2-2	0	33.53	30.037	***300.37***
14	Ring Balok, Rb-2	0	32.10	28.135	***281.35***
15	Kolom atas, K2-3	0	31.11	26.137	***261.37***
16	Ring Balok, Rb-3	0	34.95	32.780	***327.80***
17	Blk. arah X, Bx-3	0	34.31	31.323	***313.23***
18	Plat lantai, P4	90	38.46	31.662	***316.62***
19	Plat lantai, P5	90	42.80	39.644	***396.44***
20	Blk. arah Y, By-4	0	37.04	36.547	***365.47***

From the Table above, the compressive strength value of concrete when tested is the smallest is 26.137 Mpa or 261.37 kg / cm2.

Analysis of 2-StoreyEngineering Lecture Building (Existing)

The structure of the building is designed to hit the requirements of weak beam strength columns, when the building structure bears the influence of planned earthquakes, plastic joints in the building structure may only occur at the ends of the beams and at the foot of the column and the foot of the sliding wall only. The structure is planned to be built on hard ground (SE site class) located on Jalan Kampus Bukit, Jimbaran, Badung–Bali. Based on this location, parameters for earthquake calculation are obtained through earthquake zoning maps on the official PU website (PUSKIM) in accordance with SNI 1726-2019 which uses an analytical method to determine the dynamic response of 3-dimensional building structures that behave fully elastic to the influence of an earthquake through a method "Analysis of Various Response Spectrum" [13]. The repetition planning of reinforced concrete for each structural element follows the combination of loading as specified in the Indonesian National standard SNI 2847-2019 (Hernadi et al., 2021). Structural data includes: (1) Building Function: School / College Building, (2) 1st Floor Height to 2nd Floor: 4.27 m, (3) 2nd Floor Height to ring beam: 4.256 m, (4) Floor Plate Thickness: 120 mm, (5) Compressive Strength characteristics of existing concrete: 300 kg/cm2, (6) Steel QualityBasic Reinforcing (U): 40 MPA, (7) Quality of Sengkang Rebar (U): 24 MPA, (8) Earthquake Area: 5 (SPRMM), (9) Ground condition: Hard.

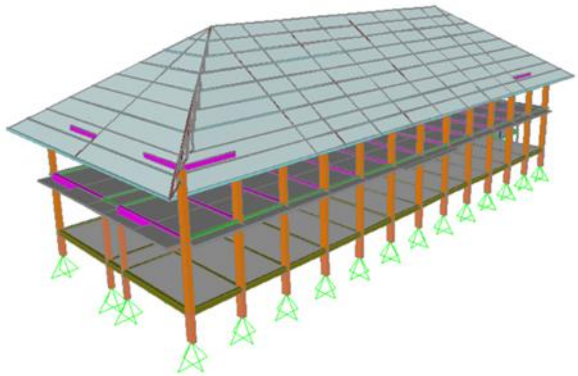


Figure 2. 3D Structure System

After modeling process, the structure and entering dead loads, live loads, and earthquake loads, results will be obtained in the form of the number of reinforcement from each structural element on sloofs, columns, and beams. Here is a table of SAP 2000 V 14 repeat results. The result obtained is that the maximum existing column reinforcement area is 15.68 cm2 which is the minimum reinforcement area because Rho (ρ) or the ratio of column reinforcement area with column cross-section is 1%. This means that the dimensions of the columns used in civil engineering lecture buildings are oversized (can be reduced again or meaning they can carry a greater load) (Kumar & Choudhury, 2018; Zhang et al., 2011).

Building Analysis Engineering Lecture Sipil 3 Floors (Addition)

Based on the results of the analysis using the SAP 200 program. V14 is determined that in existing buildings using large column dimensions, this means that the columns in the civil engineering lecture building are able to carry a larger load or the civil engineering lecture building can be increased in capacity from the existing building which is 2 floors to 3 floors.

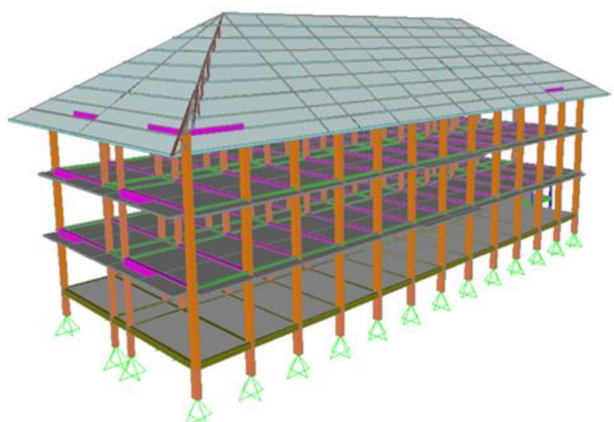
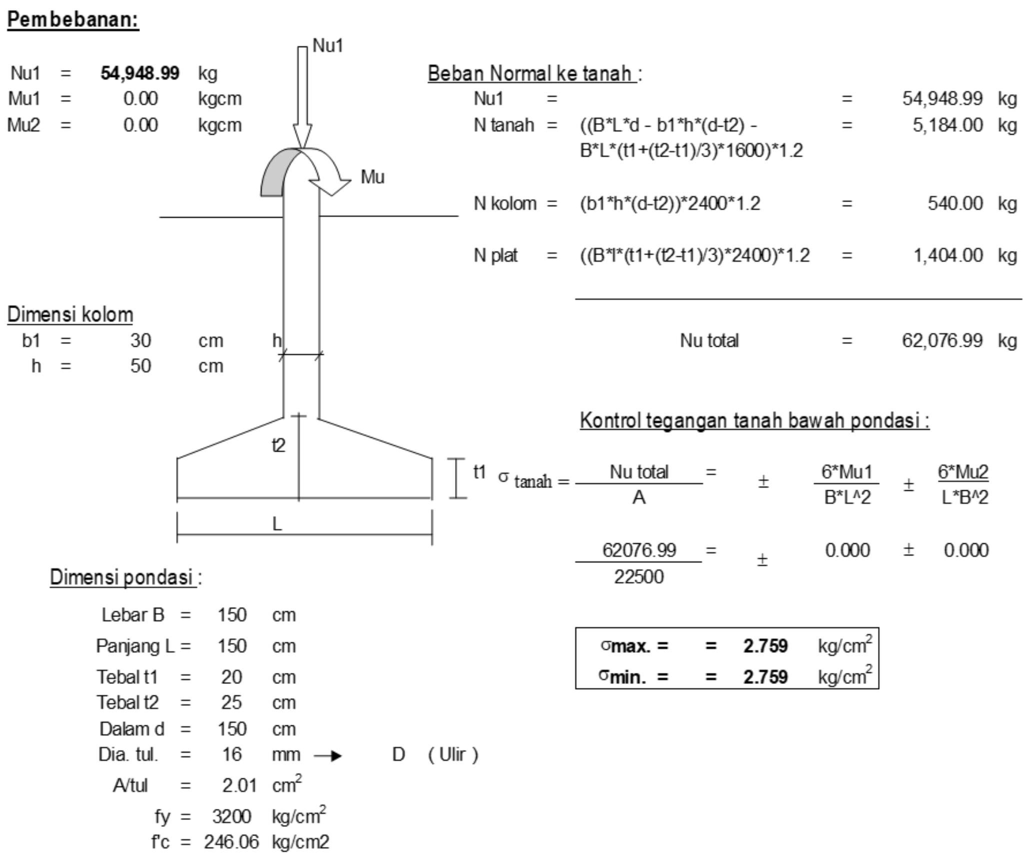


Figure 3. 3D Structure System

After modeling the structure and entering dead loads, live loads, and earthquake loads, results will be obtained in the form of the number of reinforcements from each structural element on sloofs, columns, and beams. The result is that the maximum area of column reinforcement on the 1st floor (K30/501) is 22.47 cm2 where the ratio of column reinforcement area to its cross-sectional area (ρcolumn) = 1.5% is smaller than 4%, this means that the column is safe in carrying gravity loads and earthquake loads that occur (Williamson et al., 2022; Rosenzweig et al., 2013).

Calculation of Existing Foundation Strength

Based on the results of the joint reaction in SAP 2000 V14 using the maximum axial force (F3) = 54,948.99 kg, after calculating by entering the dimensions of the existing foundation (150x150 cm) it was found that the voltage that occurred was 2.759 kg / cm2 exceeding the ground permit voltage (Ϭ') = 1.133 kg / cm2, so the existing foundation was not able to bear the axial force of the 3rd floor lecture building.

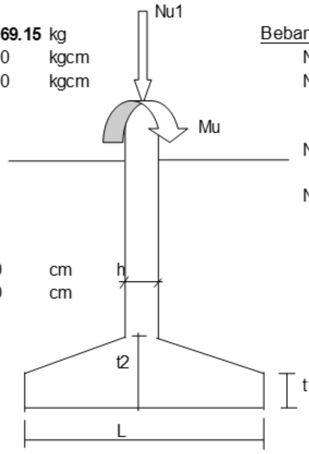


Calculation of Column / Combined Foundation Strength

Due to the existing foundation is not able to bear the axial force of the 3rd floor lecture building, the existing foundation must be strengthened in order to be able to bear the axial force by using a combined foundation / column foundation.

Pembebanan:

Nu1 = **1,641,969.15** kg
Mu1 = 0.00 kgcm
Mu2 = 0.00 kgcm



Beban Normal ke tanah :

Nu1 =		=	1,641,969.15	kg
N tanah =	((B*L*d - b1*h*(d-t2) - B*L*(t1+(t2-t1)/3)*1600)*1.2	=	497,491.20	kg
N kolom =	(b1*h*(d-t2))*2400*1.2	=	540.00	kg
N plat =	((B*l*(t1+(t2-t1)/3)*2400)*1.2	=	126,079.20	kg
	Nu total	=	2,266,079.55	kg

Dimensi kolom

b1 = 30 cm
h = 50 cm

Kontrol tegangan tanah bawah pondasi :

$$\sigma_{tanah} = \frac{Nu\ total}{A} = \pm \frac{6*Mu1}{B*L^2} \pm \frac{6*Mu2}{L*B^2}$$

$$\frac{2266079.55}{2020500} = \pm 0.000 \pm 0.000$$

σ max. =	=	**1.122**	kg/cm^2
σ min. =	=	**1.122**	kg/cm^2

Dimensi pondasi :

Lebar B = 150 cm
Panjang L = 13470 cm
Tebal t1 = 20 cm
Tebal t2 = 25 cm
Dalam d = 150 cm
Dia. tul. = 16 mm → D (Ulir)
A/tul = 2.01 cm^2
fy = 3200 kg/cm^2
f'c = 246.06 kg/cm2

Momen Plat pondasi (Mu plat) $= \frac{\sigma\ max. * B * (0.5\ L - 0.5h)^2}{2}$

= **3,787,238,020.31** kg.cm

Momen Penampang plat (Mp) = 0.85 * f'c *a*B (dx - a/2)

= **3,791,434** kg.cm > Mu plat
(Tulangan tunggal)

Based on the results of the joint reaction in SAP 2000 V14 using combined axial force (F3) = 1,641,969.15 kg, after calculating by entering the dimensions of the combined foundation / lane (150 x 13,470 cm) it was found that the voltage that occurred was 1.122 kg / cm2 smaller than the ground permit voltage (Ϭ') = 1.133 kg / cm2, so the combined foundation / column can be used to be able to bear the axial force of the 3rd floor lecture building (Yao et al., 2010; Yang et al., 2020).

4 Conclusion

The maximum area of column reinforcement on the 1st floor (K30/501) is 22.47 cm2 where the ratio of column reinforcement area to its cross-sectional area (ρcolumn) = 1.5% less than 4%, this means that the column is safe in carrying gravity loads and earthquake loads that occur. The capacity of the lecture building at the Bali State Polytechnic can be increased because the strength of the existing lecture build-ing structure is able to bear the load due to the addition of space capacity from 2 floors to 3 floors. The dimensions of the existing foundation (150 x 150 cm) obtained the voltage that occurs is 2.759 kg/cm2 exceeding the ground permit voltage (Ϭ') = 1.133 kg/cm2, so the existing foundation is not able to bear the axial force of the 3rd floor lecture building. The combined foundation / column (150 x 13,470 cm) obtained the voltage that occurs is 1,122 kg / cm2 smaller than the ground permit voltage (Ϭ') = 1,133 kg / cm2, so the combined foundation / column can be used to be able to bear the axial force of the 3rd floor lecture building. It can be recommended that the lecture building at the Bali State Polytechnic can be added 1 floor above the existing building. that we get is that there are still many contractors who have not received training or socialization, which means that contractors still do not understand the regulations and system of the e-tender.

Conflict of interest statement
The authors declared that they have no competing interest.

Statement of authorship
The authors have a responsibility for the conception and design of the study. The authors have approved the final article.

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