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Room Capacity Improvement for Classrooms at Bali State Polytechnic

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Abstract

Bali State Polytechnic is one of the vocational universities in Indonesia. Located in South Kuta District, Badung Regency, Bali, the Bali State Polytechnic is an attraction for high school/vocational school graduates from within and outside the region to receive education here. The increase in interest from prospective students is not in line with the addition of classroom facilities. The Bali State Polytechnic requires the addition of classrooms above 50 rooms, but to build a new building, the area used is no longer there. Therefore, one of the steps to add a classroom is to add a building floor to the exterior building. For this reason, it is necessary to conduct a study in terms of structural strength and financing for the addition of the floor. The structural study used is to conduct a hammer test and check the size of the foundation. The results of this study, by conducting a study on the strength of the structure, can be recommended to add floors, but with the reinforcement of the column foundation and the addition of columns on the 2nd floor. With the addition of the floor, the required cost is IDR 8,871,123,281 excluding tax.

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1 Introduction

The lecture building at the Bali State Polytechnic is currently functioning as a place for teaching and learning, lecturer rooms, and department management rooms. The type of building is the same in all Departments at PNB, which consists of 2 floors with a height of approximately 7 m built on hard soil. The facilities and infrastructure owned by PNB can currently be grouped into: buildings, lab/workshop/workshop equipment, PBM supporting equipment, and learning infrastructure (desks, chairs, whiteboards/whiteboards). Until 2021, PNB ideally needs 214 classrooms, while the number of available spaces is 142 classrooms. The teaching and learning process 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 the Bali State Polytechnic (Suasira et al., 2023).

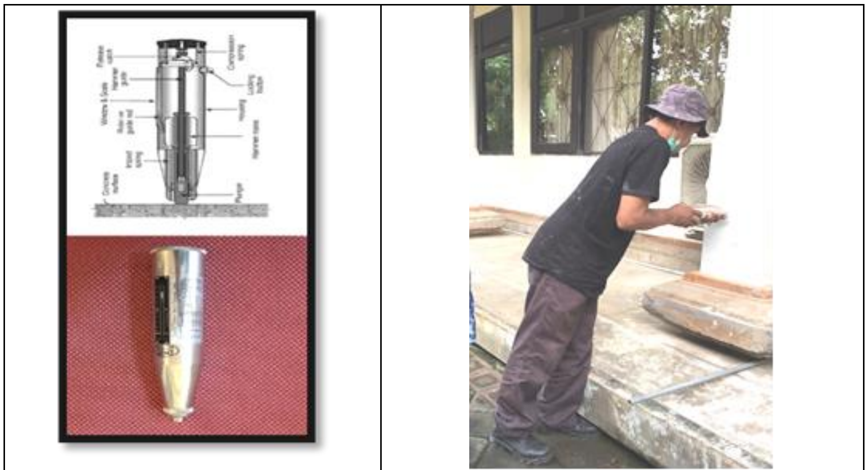
The data needed in this study are soil data, technical drawings, and the type of foundation. These data need to be studied on the strength of the structure through the analysis of the Hammer Test to determine the quality of the concrete of the building (Wahyudiono et al., 2023). This test is only to determine the strength of the concrete from the surface of the concrete skin (Suseno, 2022). The results of this hammer test are greatly influenced by the concrete surface, the type of aggregate, and the type of cement (Jedidi, 2020). Several studies have been conducted to determine the causes of the failure of a structure. Structural failure will occur along with the increase in existing load, especially failure in the column, so a column structure must be planned properly and carefully (Wiyana, 2016). In addition, the function of building use is also able to be one of the factors that cause damage to buildings. In building a building, the selected structural elements must follow the function of the building later. Meanwhile, in the planning of a structural element, the load distribution model, especially for main structures such as beams and columns, must have data sourced from the location to find out the real condition of the building or structure so that it can be recommended structural reinforcement that is suitable for its planning (Baloi & Price, 2003; Frimpong et al., 2003). The Concrete Hammer Test is the most popular concrete test method today. This test is carried out to predict the stress value of concrete in a structural building (Sanchez & Tarranza, 2014). The most commonly used structural calculation analysis is using the SAP 2000 program and is guided by SNI 1727-2020 (Oktarina & Darmawan, 2015). Planning the project cost budget is one of the stages that must be passed before the implementation begins. By conducting a cost analysis, it can be known which budget must be prepared. One of the concepts that can be used is WBS (Suardika et al., 2019).

2 Materials and Methods

The existing picture of the building that is the object of the study is a building with a total of 2 floors with a floor-to-floor height of 4.2 m. This building is used as a lecture building. The soil condition is hard soil, with strong concrete characteristics of 300 kg/cm2, and the quality of the main reinforcement steel is 40 MPa, the Sengkang reinforcement is 24 Mpa, located in the earthquake area 5, by the method of the Medium Moment Bearing Frame System (Tajunnisa et al., 2014). The primary data needed is concrete strength data, obtained from the hammer test, as well as the strength of the building foundation through the foundation excavation process (Panedpojaman & Tonnayopas, 2018; Wang & Wan, 2019). Meanwhile, additional data needed are as-built drawings and loading regulations. The creation of structural models following shop drawings using the SAP 2000.14.2.2 program, by taking reference from SNI 1727-2020, SNI 2847-2019, SNI 1726-2019 and SNI 1729-2020 are building standards. By inputting the existing concrete quality material and load according to the Indonesian national standard in the SAP 2000.14.2.2 program, later data will be generated in the form of deep forces so that the results can be used to assess the strength of the building. The modeling was done by adding one floor above the existing building. The result of the above structural analysis is the reinforcement of the structure for the addition of one floor above it. From this data, it was continued by analyzing the project cost for the addition of the floor.

3 Results and Discussions

Testing the strength of the structure through hammer tests and measuring the foundation of the existing building. The test tool used is the Schmidt Hammer Test (Kong et al., 2021; Kazemi et al., 2019). This test was carried out at 20 points consisting of column structures, beams, and floor plates that were randomly taken (Harahap et al., 2021). The method of operating the tool is very easy but you have to be careful. The working principle is to apply an impact load to the concrete surface using a mass that is activated by using a certain amount of energy. Because there is a collision between the mass and the concrete surface, the mass will be reflected. The measured mass reflection distance indicates the hardness of the concrete surface. The hardness of concrete can indicate its compressive strength (Wior et al., 2015). This hammer test cannot be used for work with natural stone because it can damage the material (Přikryl & Snížek, 2023).



(a)	(b)

Figure 1. (a) Schmidt Concrete Test Hammer – Type N; (b) Implementation of Hammer Test

Based on the test results, data was obtained that from 20 test points, the smallest value was 261.37 kg/cm2

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***

Figure 2. Hammer test results

The loading analysis begins with an existing building with a total of 2 floors. The study is carried out by modeling the structure and including dead loads, live loads, and earthquake loads, later the results will be obtained in the form of the number of reinforcements from each structural element on the sloop, column, and beam (Prayoga, 2021). Loading is inserted with a dead load consisting of the specimen, floor covering, ceiling and hanging, and MEP with a total of 100 kg/m2. The fixed load of the school building is 250 kg/m2. Fixed loads for roofs are 50 kg/m2 dead load and 20 kg/m2 live load.

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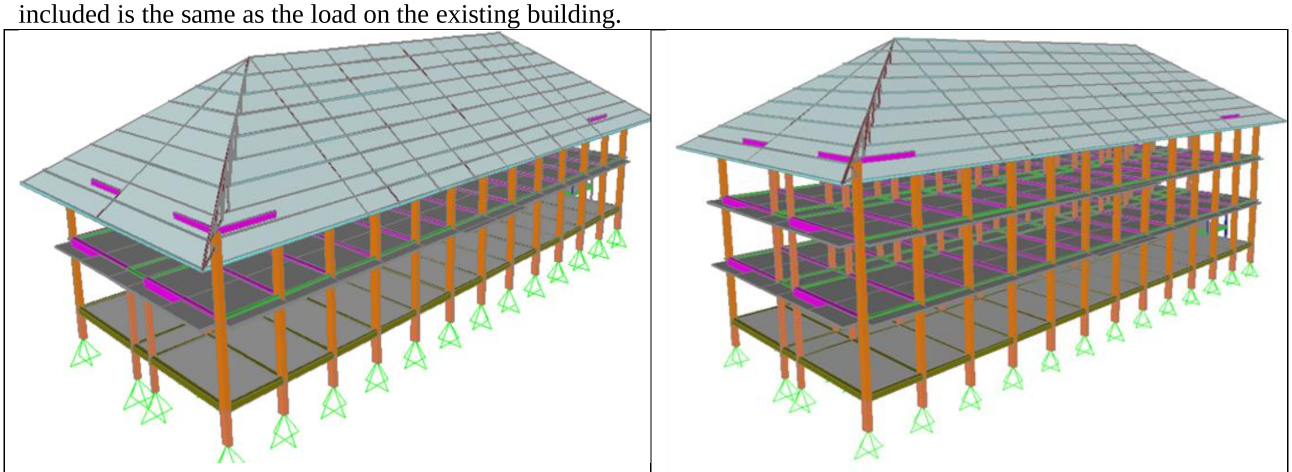
TABLE: Concrete Design 1 - Column Summary Data - ACI 318-05/IBC2003

Frame	DesignSect	DesignType	DesignOpt	Location	PMMCombo	PMMArea	VMajRebar	VMinRebar
Text	Text	Text	Text	cm	Text	cm2	cm2/cm	cm2/cm
176	k30501	Column	Design	0.00	COMB6	15.00	0.05	0.07
176	k30501	Column	Design	213.50	COMB6	15.00	0.05	0.07
176	k30501	Column	Design	427.00	COMB6	15.00	0.05	0.07
185	k30501	Column	Design	0.00	COMB6	15.00	0.05	0.07
185	k30501	Column	Design	213.50	COMB6	15.00	0.05	0.07
185	k30501	Column	Design	427.00	COMB6	15.00	0.05	0.07
188	k30501	Column	Design	0.00	COMB6	15.00	0.04	0.08
188	k30501	Column	Design	213.50	COMB6	15.00	0.04	0.08
188	k30501	Column	Design	427.00	COMB5	15.63	0.04	0.08
197	k30501	Column	Design	0.00	COMB6	15.00	0.04	0.08
197	k30501	Column	Design	213.50	COMB6	15.00	0.04	0.08
197	k30501	Column	Design	427.00	COMB5	15.68	0.04	0.08
200	k30501	Column	Design	0.00	COMB6	15.00	0.04	0.08
200	k30501	Column	Design	213.50	COMB6	15.00	0.04	0.08
200	k30501	Column	Design	427.00	COMB6	15.00	0.04	0.08
209	k30501	Column	Design	0.00	COMB6	15.00	0.04	0.08
209	k30501	Column	Design	213.50	COMB6	15.00	0.04	0.08
209	k30501	Column	Design	427.00	COMB6	15.00	0.04	0.08
212	k30501	Column	Design	0.00	COMB6	15.00	0.00	0.00
212	k30501	Column	Design	213.50	COMB6	15.00	0.05	0.08
212	k30501	Column	Design	427.00	COMB6	15.00	0.05	0.08
221	k30501	Column	Design	0.00	COMB6	15.00	0.00	0.00
221	k30501	Column	Design	213.50	COMB6	15.00	0.05	0.08
221	k30501	Column	Design	427.00	COMB6	15.00	0.05	0.08
224	k30501	Column	Design	0.00	COMB6	15.00	0.04	0.08
224	k30501	Column	Design	213.50	COMB6	15.00	0.04	0.08
224	k30501	Column	Design	427.00	COMB6	15.00	0.04	0.08
233	k30501	Column	Design	0.00	COMB6	15.00	0.04	0.08
233	k30501	Column	Design	213.50	COMB6	15.00	0.04	0.08
233	k30501	Column	Design	427.00	COMB6	15.00	0.04	0.08
236	k30501	Column	Design	0.00	COMB6	15.00	0.00	0.00
236	k30501	Column	Design	213.50	COMB6	15.00	0.05	0.08
236	k30501	Column	Design	427.00	COMB6	15.00	0.05	0.08
245	k30501	Column	Design	0.00	COMB6	15.00	0.00	0.00
245	k30501	Column	Design	213.50	COMB6	15.00	0.05	0.08
245	k30501	Column	Design	427.00	COMB6	15.00	0.05	0.08
248	k30501	Column	Design	0.00	COMB6	15.00	0.04	0.08
248	k30501	Column	Design	213.50	COMB6	15.00	0.04	0.08
248	k30501	Column	Design	427.00	COMB6	15.00	0.04	0.08
257	k30501	Column	Design	0.00	COMB6	15.00	0.04	0.08
257	k30501	Column	Design	213.50	COMB6	15.00	0.04	0.08
257	k30501	Column	Design	427.00	COMB6	15.00	0.04	0.08
260	k30501	Column	Design	0.00	COMB6	15.00	0.00	0.00
260	k30501	Column	Design	213.50	COMB6	15.00	0.05	0.08
260	k30501	Column	Design	427.00	COMB6	15.00	0.05	0.08
269	k30501	Column	Design	0.00	COMB6	15.00	0.00	0.00
269	k30501	Column	Design	213.50	COMB6	15.00	0.05	0.08
269	k30501	Column	Design	427.00	COMB6	15.00	0.05	0.08
272	k30501	Column	Design	0.00	COMB6	15.00	0.04	0.08
272	k30501	Column	Design	213.50	COMB6	15.00	0.04	0.08
272	k30501	Column	Design	427.00	COMB6	15.00	0.04	0.08
281	k30501	Column	Design	0.00	COMB6	15.00	0.04	0.08
281	k30501	Column	Design	213.50	COMB6	15.00	0.04	0.08
281	k30501	Column	Design	427.00	COMB6	15.00	0.04	0.08
284	k30501	Column	Design	0.00	COMB6	15.00	0.05	0.08
284	k30501	Column	Design	213.50	COMB6	15.00	0.05	0.08
284	k30501	Column	Design	427.00	COMB6	15.00	0.05	0.08
293	k30501	Column	Design	0.00	COMB6	15.00	0.00	0.00
293	k30501	Column	Design	213.50	COMB6	15.00	0.05	0.08
293	k30501	Column	Design	427.00	COMB6	15.00	0.05	0.08
296	k30501	Column	Design	0.00	COMB6	15.00	0.04	0.08
296	k30501	Column	Design	213.50	COMB6	15.00	0.04	0.08
296	k30501	Column	Design	427.00	COMB6	15.00	0.04	0.08
305	k30501	Column	Design	0.00	COMB6	15.00	0.04	0.08
305	k30501	Column	Design	213.50	COMB6	15.00	0.04	0.08
305	k30501	Column	Design	427.00	COMB6	15.00	0.04	0.08
308	k30501	Column	Design	0.00	COMB6	15.00	0.04	0.08
308	k30501	Column	Design	213.50	COMB6	15.00	0.04	0.08
308	k30501	Column	Design	427.00	COMB5	15.67	0.04	0.08
317	k30501	Column	Design	0.00	COMB6	15.00	0.04	0.08
317	k30501	Column	Design	213.50	COMB6	15.00	0.04	0.08
317	k30501	Column	Design	427.00	COMB5	15.65	0.04	0.08
320	k30501	Column	Design	0.00	COMB6	15.00	0.05	0.07
320	k30501	Column	Design	213.50	COMB6	15.00	0.05	0.07
320	k30501	Column	Design	427.00	COMB6	15.00	0.05	0.07
329	k30501	Column	Design	0.00	COMB6	15.00	0.05	0.07
329	k30501	Column	Design	213.50	COMB6	15.00	0.05	0.07
329	k30501	Column	Design	427.00	COMB6	15.00	0.05	0.07
					Max	15.68	ρkolom =	0.010
								1%

Figure 3. SAP results of existing buildings

From the results of the analysis, it was obtained that the maximum existing column reinforcement area is 15.68 cm2, which is the minimum reinforcement area because Rho (ρ) or the ratio of the column reinforcement area to the column cross-section is 1%. This means that the dimensions of the columns used in the building are too large (it can be reduced again or it can bear a larger load).

The next load is carried out on the building with a total of 3 floors. From the results of the analysis on existing buildings, it can be seen that the structural columns are too large or can still bear a larger load. The load that is included is the same as the load on the existing building.

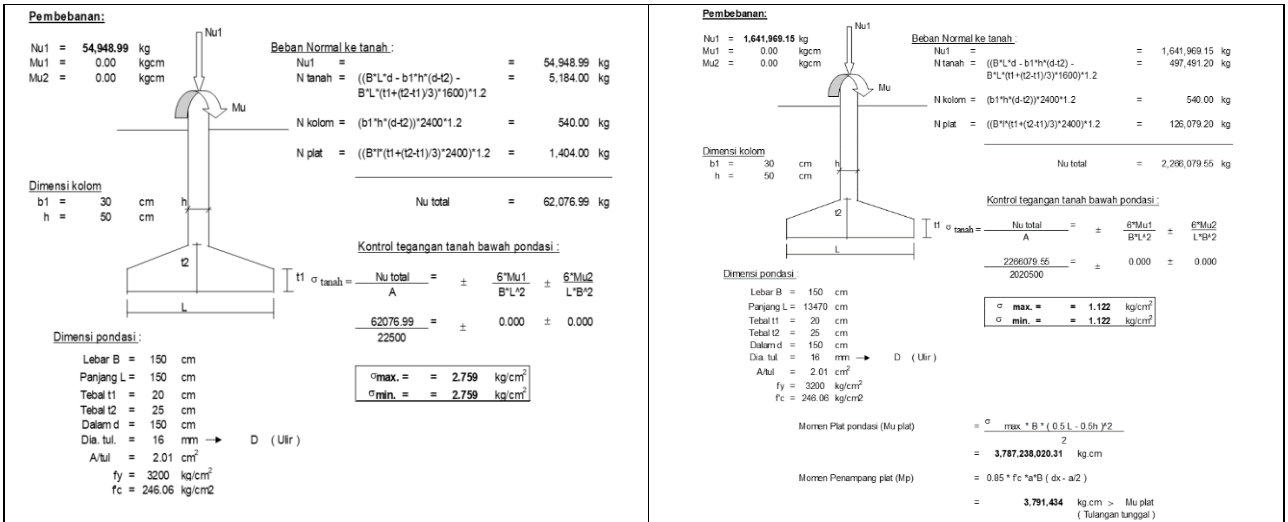


(a) (b)

Figure 4. (a) Existing buildings; (b) building with additional floors

From the results of the analysis on the 3-storey building, the result was obtained that the maximum area of column reinforcement on the 1st floor (K30/501) was 22.47 cm2 where the ratio of the column reinforcement area to its cross-sectional area (ρcolumn) = 1.5% was less than 4%, this means that the column is safe in bearing the gravity load and the earthquake load that occurred.

Through checking the existing foundation, the dimensions used were 150 x 150 cm with a thickness of 25 cm. Furthermore, the results of structural modeling including dead loads, live loads, and earthquake loads will later be obtained in the form of the magnitude of the axial force (F3) and moment (M) that occurs at each point of the foundation) the stress that occurs is 2.759 kg/cm2 exceeding the soil allowable voltage (Ϭ') = 1.133 kg/cm2, so the existing foundation is not able to bear the axial force of the 3rd floor lecture building. To anticipate this, an analysis of the combined foundation was carried out.



(a)	**(b)**

Figure 5. (a) analysis of existing foundations; (b) Joint foundation analysis

Based on the results of the joint reaction in SAP 2000 V14 using the combined axial force (F3) = 1,641,969.15 kg, after calculating by entering the dimensions of the combined foundation/column (150 x 13,470 cm) it was obtained that the stress that occurred was 1.122 kg/cm2 less than the soil allowable stress (Ϭ') = 1.133 kg/cm2, so the combined foundation/column could be used to be able to bear the axial force of a lecture building with 3 floors. From the results of the calculation of the strength of the structure by adding one floor, it can be done by adding a combined foundation.

The cost estimate used in this study is a rough estimate. This rough estimate aims to indicate the magnitude of the construction cost at the very early stage. The data needed in compiling a rough estimate are records/data about the prices and results of the implementation of similar buildings that have been implemented. The project drawings in general are plans, and they appear, with details in the form of assumptions according to the experience of building similar buildings. Standard unit prices can be seen both through print media and periodically published by related agencies, including unit prices of materials, tools, labor wages, and unit prices of work. The rough estimation method applied is the deep broad method. Superficial methods are the most commonly used methods today for estimation approach (RAB groping). The estimate is easy to calculate and the cost is expressed in a form that is easy to understand for construction clients in general. For each floor is measured, then the total floor area obtained is multiplied by the price per square meter. This method is suitable for construction projects of schools or buildings where the floor height is fixed. Similar to the unit method, the price of buildings per square meter is obtained based on data from similar projects that have been completed. The estimated work carried out starts at the preparatory stage, structural work, architecture, and until the stage of mechanical and electrical installation work is carried out. This estimate is only for building work, excluding exterior and interior work for learning.

a) Preparatory Work
   The preparatory work items here include all the work done before the main work is carried out, such as the measurement and installation of bow planks, the installation of project fences, and the demolition work. The demolition work referred to here is the demolition work of reinforced concrete structures on the 1st floor

including ceramic pairs. The purpose of dismantling this floor is to install foundation reinforcement with the addition of a column plate foundation. The next demolition was carried out on the 2nd floor, namely the dismantling of the roof covering because an additional floor above it will be built to the 3rd floor.

b) 1st Floor Work
The work items on the 1st floor are concrete foundation work, lane plates and floor plates, and floor covering installation work. This item exists because it was previously dismantled to add reinforcement to the foundation. The quantity calculation is carried out based on the details of similar building drawings.

c) 2nd Floor Work
The 2nd-floor work items consist of the addition of structural columns including the installation of ancor, ceiling work, and repainting of the ceiling and walls. The quantity calculation is carried out based on the details of similar building drawings.

d) 3rd Floor and Roof Works
The 3rd floor work item is the addition of a new floor consisting of concrete structure work, finishing, and MEP. The quantity calculation is carried out based on the details of similar building drawings. The work items on the roof floor consist of structural, architectural, and roof covering work.

Table 1
Total estimated cost of adding floors

It	Job Description	Total Price (Rp)
A.	***Preparatory Work***	**478.146.259**
B	***1st Floor Work***	**1.419.203.023**
I	Concrete Works	956.907.100
II	Floor Covering Work	378.417.661
III	Painting Jobs	83.878.262
C	***Floor Iii***	**430.662.271**
I.	Concrete Works	232.582.567
II	Ceiling Work	114.201.442
III.	Painting Jobs	83.878.262
D	***Floor Iii***	**2.747.369.563**
I	Concrete Works	1.464.523.903
II.	Wall Work	362.693.638
III.	Wall and Floor Cladding Work	508.784.722
IV.	Door and Window Work	165.000.000
V.	Ceiling Work	114.201.442
VI.	Painting Jobs	83.878.262
VII.	Sanitation Jobs	48.287.595
E	***Roof floor***	**2.903.289.220**
I	Concrete Works	129.908.642
II	Roof Truss and Roof Cover Work	2.456.151.496
III	Ceiling Work	295.628.530
IV	Painting Jobs	21.600.552
F	***Pack. Other***	***17.880.695***
I	Bathroom Mirror Work	2.721.535
II	Sink Undertable Work	8.750.031
III	Ladder Rally Work	4.973.045
IV	Writing and Logo Work	1.436.084
G	**MEP**	**385.084.721**
	Total Physical Costs	**8.381.635.753**
	Construction Management Costs (4.89 %)	**409.861.988**
	Activity Manager Fees (0.95 %)	**79.625.540**
	Total Cost	**8.871.123.281**

The total cost required for the addition of 1 floor is IDR 8,871,123,281

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

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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References

Baloi, D., & Price, A. D. (2003). Modelling global risk factors affecting construction cost performance. *International journal of project management*, *21*(4), 261-269. https://doi.org/10.1016/S0263-7863(02)00017-0

Frimpong, Y., Oluwoye, J., & Crawford, L. (2003). Causes of delay and cost overruns in construction of groundwater projects in a developing countries; Ghana as a case study. *International Journal of project management*, *21*(5), 321-326. https://doi.org/10.1016/S0263-7863(02)00055-8

Harahap, A. K., Purba, V. E., & Nainggolan, E. D. (2021). ANALISA KERUSAKAN BANGUNAN AKIBAT GEMPA (Studi Kasus kerusakan Bank Aceh di Kota Sigli akibat gempa pada tahun 2010). *Jurnal Santeksipil*, *2*(1), 1-7.

Jedidi, M. (2020). Evaluation of the quality of concrete structures by the rebound hammer method. *Current Trends in Civil & Structural Engineering*, *5*(5), 1-7.

Kazemi, M., Madandoust, R., & de Brito, J. (2019). Compressive strength assessment of recycled aggregate concrete using Schmidt rebound hammer and core testing. *Construction and Building Materials*, *224*, 630-638. https://doi.org/10.1016/j.conbuildmat.2019.07.110

Kong, F., Xue, Y., Qiu, D., Gong, H., & Ning, Z. (2021). Effect of grain size or anisotropy on the correlation between uniaxial compressive strength and Schmidt hammer test for building stones. *Construction and Building Materials*, *299*, 123941. https://doi.org/10.1016/j.conbuildmat.2021.123941

Oktarina, D., & Darmawan, A. (2015). Analisa Perbandingan Rangka Atap Baja Ringan Dan Rangka Atap Kayu Dari Segi Analisis Struktur Dan Anggaran Biaya. *Konstruksia*, *7*(1).

Panedpojaman, P., & Tonnayopas, D. (2018). Rebound hammer test to estimate compressive strength of heat exposed concrete. *Construction and Building Materials*, *172*, 387-395. https://doi.org/10.1016/j.conbuildmat.2018.03.179

Prayoga, D. (2021). Evaluasi Perencanaan Struktur Atas Hotel Grand Central Premier Medan. JURNAL ILMIAH TEKNIK SIPIL, 10(1), 88-94.

Přikryl, R., & Snížek, P. (2023). Critical assessment of the “non-destructiveness” of Schmidt hammer test on monumental sandstones: A microscopic and microstructural approach. Journal of Cultural Heritage, 59, 247-254. https://doi.org/10.1016/j.culher.2022.12.011

Sanchez, K., & Tarranza, N. (2014). Reliability of rebound hammer test in concrete compressive strength estimation. *Int. J. Adv. Agric. Environ. Eng*, *1*(2), 198-202.

Suardika, I. N., Putera, I. G. A. A., & Yana, A. A. G. A. (2019). Pengembangan Sistem Estimasi Biaya Proyek Konstruksi Berbasis Komputer. *Jurnal Spektran*, *7*(1), 85-92.

Suasira, I. W., Suardika, I. N., Jaya, I. M., Yuni, N. K. S. E., & Yuliana, N. P. I. (2023). Improvement studies for building capacity at Bali State Poly-technic. *International Research Journal of Engineering, IT and Scientific Research*, *9*(4), 182–192. https://doi.org/10.21744/irjeis.v9n4.2350

Suseno, D. P. (2022). Analisis Struktur Bangunan Hotel Sato Kudus di Kota Kudus. *Journal of Civil Engineering and Technology Sciences*, *1*(1), 7-16.

Tajunnisa, Y., Chadaffi, M., & Ramadhaniawan, V. (2014). Perbandingan evaluasi kinerja bangunan gedung tahan gempa antara metode SRPMM dan SRPMK. *Jurnal Aplikasi Teknik Sipil*, *12*(1), 1-16.

Wahyudiono, S., Kumalasari, A. I., & Septiropa, Z. (2023). Asesmen Kekuatan Struktur Bangunan Terkait Penambahan Lantai Gedung Asrama Pondok Pesantren Entrepreneur Muhammadiyah (PPEM) Gondanglegi Kabupaten Malang. *Jurnal Pengabdian Dan Peningkatan Mutu Masyarakat (Janayu)*, *4*(1).

Wang, M., & Wan, W. (2019). A new empirical formula for evaluating uniaxial compressive strength using the Schmidt hammer test. *International Journal of Rock Mechanics and Mining Sciences*, *123*, 104094. https://doi.org/10.1016/j.ijrmms.2019.104094

Wior, C. E., Wallah, S. E., & Pandaleke, R. (2015). Kajian kuat tekan beton dan kuat tarik baja tulangan gedung teknik arsitektur dan elektro universitas Sam Ratulangi Manado pasca kebakaran. *Jurnal Sipil Statik*, *3*(4).

Wiyana, Y. E. (2016). Analisis Kegagalan Konstruksi dan Bangunan dari Perspektif Faktor Teknis. *Wahana Teknik Sipil: Jurnal Pengembangan Teknik Sipil*, *17*(2).