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Design Development of Building Materials Lab for Teacher Education Institutes on Vocational and Academic Program

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Abstract

This study aims at creating an integrated design of a building material laboratory for Teacher Education Institutes (TEIs) in higher education of vocational and academic programs to support the effective and efficient learning processes. Development of a building materials laboratory design in the form of a 2-story floor plan with a capacity of 20 students. This research belongs to development research using the ADDIE model. The research design was prepared through a Focus Group Discussion (FGD) consisting of 10 respondents involving (1) the coordinator of the TEI building materials lab; (2) the construction industry; and (3) the architecture expert. The collecting data using a questionnaire with an assessment of 2 aspects, namely the completeness of communicating spatial drawings. Data analysis using descriptive statistics to assess the feasibility of the layout drawings of the building materials laboratory was assessed by 2 building planning experts. Data analysis using descriptive statistics to assess the feasibility of the layout drawings of the building materials laboratory was assessed by 2 building planning experts. The results of the feasibility assessment of building materials laboratory drawings obtained 80.4% in the very feasible category. The research results revealed that (1) the practice course contents of building materials in the TEIs of Vocational and Academic program were testing sand, gravel, cement, bricks, light bricks, paving blocks, wood, concrete reinforcing steel, light steel, and concrete technology; (2) the 2-story laboratory floor plan that was developed has a total area of 387 m^2, all of which are integrated into one area.

Keywords: Lab design, building material, teacher education institutes, vocational and academic program

Introduction

The construction industry sectors are growing rapidly boosting infrastructure development to elevate the chain of national economic development (Daryono et al., 2020; Saifurrahman et al., 2021). According to online media "Indipendesi.com", the infrastructure development targets include 1000 km of toll roads, new roads of 2,650 km, 65 reservoirs/dams, and one million public houses (Independensi.Com, 2019). At the end of 2020, the Ministry of Public Works and Public Housing has completed the toll road of Cileunyi-Sumedang-Dawuan (Cisumdawu) with a length of 61.7 km (Kementerian Pekerjaan Umum dan Perumahan Rakyat, 2020). Based on a news release from the Ministry of Public Works and Public Housing, the growth of the construction sector in Indonesia reaches 6 to 7 percent per year, and it is predicted to reach 10-15 percent in 2050 aligning with the Master Plan for the Acceleration and Expansion of Indonesia's Economic Growth. This growth of construction sectors will be parallel to its challenges in the future, so the demands of efficiency, effectiveness, and accountability in the implementation of construction projects will be even higher (Daryono et al., 2020).

Along with the rapid construction development in Indonesia, the government needs a lot of skilled workers in the field of civil engineering, especially graduates of the diploma or vocational education program who are ready to compete in the world of work (Kesai et al., 2018). Vocational education is expected to produce graduates with 8 competencies consisting of communication skills (Coetzer et al., 2020; Saleh et al., 2019), critical and creative thinking (Clemente et al., 2016; Rodríguez et al., 2019), digital literacy (Beicht & Walden, 2019; Polizzi, 2020; Purnama et al., 2021), self-development skills (Nurtanto et al., 2019; Setyadi et al., 2021), interpersonal skills (Liu et al., 2020; Nurtanto et al., 2020), multilingual literacy (Boonk et al., 2020), problem-solving (Karabulut-Ilgu et al., 2018; McCrum, 2017), technological skills (Coetzer et al., 2020; Kusuma et al., 2021; Olazaran et al., 2019).

The government has provided wide opportunities for universities in Indonesia including Teacher Education Institutes (TEIs) as teacher-producing institutions to run

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vocational education programs. In reality, most of the tertiary institutions that hold vocational education have separate facilities and infrastructures that impact on high costs of education. The laboratory is a distinctive feature of vocational education for skill development. Building materials lab has been listed as one of the main components in the civil engineering program of TEIs. This lab functions to support the teaching and learning process, research activities as well as public service that can become income-generating assets. To increase efficiency and optimize the use of laboratories in higher education, it is necessary to develop an integrated lab of building materials that can be used for the vocational and academic program. This research is providing a design of materials building laboratory for 20 students in the form of a layout drawing.

The Practical Course Content of Building Materials and Concrete Technology

The practice of building materials and concrete technology are compulsory courses in the civil engineering study program (Azeko et al., 2016; Burke et al., 2018; Simpson & Bester, 2017). The building materials course learn about all materials of natural origin and other materials used for construction purposes including stone, bricks, cement, pozzolan, sand, gravel, water, concrete, wood & industrial wood products, glass, cast iron and steel, aluminum, and alloys, metals and alloys, paint, rubber, plastic, asphalt, bitumen, adhesives, ceramic, asbestos, geosynthetics, water proof, flooring, roofing materials, and pipes (Deng et al., 2020; Li et al., 2019; Nwodo et al., 2018; Wei, 2019; Xia et al., 2020). In reality, only a few materials are presented to college students of civil engineering due to the limited occasion, urgency, and lack of infrastructure and facilities (Chang et al., 2021; Valikhani et al., 2021).The inadequate infrastructure and facilities have been a common issue in civil engineering study programs, one of which is building materials labs (Chang et al., 2021; Lepage et al., 2019; Shou & Huang, 2020)requiring further design considerations. Researchers across the world have tried to characterize this issue through a combination of field experience, modeling, and controlled laboratory investigations. However, integration of these research outputs in building enclosure design analysis is an unfinished agenda, partly due to the lack of coordination between engineering researchers, building enclosure designers, and biologists. This paper critically reviews the research to date on biodeterioration models of building materials (e.g., wood. The first step in planning the building materials labs for TEIs is assessing (1) graduates' profile; (2) graduates' learning outcomes; (3) course learning outcomes & sub-course learning outcomes. The synergy among the institutions should be done to achieve mutual agreement regarding the current learning content to respond the high demands of the world of work. Here are the TEIs that hold vocational and academic program (1) Malang State University; (2) Surabaya State University; (3) Medan State University; and (4) Yogyakarta State University.

The materials that need to be taught in the practice courses of building materials and concrete technology in the civil engineering study program of TEIs for Vocational and academic program are testing of sand, gravel, bricks, light bricks, paving blocks, roof tiles, cement, wood, lightweight steel, reinforcing steel and concrete technology. Based on the Indonesian National Standard (SNI) and American Standard Testing and Materials (ASTM), the sand testing involves natural sand and SSD (Saturated Surface and Dry) water content, specific gravity, sludge content, organic matter content, sieve analysis, zone analysis, aggregate conservation and weight of sand contents. Gravel testing includes natural gravel and SSD moisture content, water absorption, sludge content, gravel form, gravel wear, gravel hardness, sieve analysis, and gravel content weight. Cement testing discusses cement density, fineness, normal consistency, initial bonding, and final cement bonding. Bricks Testing is about the visual, water absorption, salinity, and compressive strength of bricks. Light brick testing: visual, water absorption, specific gravity, and compressive strength. Paving block testing consists of visual, water absorption, wear, specific gravity, resistance to sodium sulfate, and compressive strength test. Tile testing deals with visual, water absorption, seepage, testing the useful length and width, and the bending load of the tile. Wood testing focuses on visual, compressive strength perpendicular and parallel to fibers, tensile strength perpendicular to fibers, shear strength perpendicular to and parallel to fibers, and moisture content of the wood. Reinforcing steel testing studies visual, yield strength, tensile steel, bending test of plain and finned reinforcing steel. Mild steel testing: visual and mild steel mechanical testing. Concrete testing covers slump test, specific gravity, concrete permeability, compressive strength, split tensile strength, flexural strength, and concrete elasticity.

Material Building Labs

There are three functions of the Building Material Laboratory in TEI, i.e. supporting the teaching and learning process, through research activities for both lecturers and students, and public service. Public services include testing materials from the construction industry which play a role as a production unit to increase income-generating of higher education.

The designing process of the material building labs was done initially by surveying the Vocational Colledge of Universitas Gajah Mada, Department of Civil Engineering in Universitas Sebelas Maret, Department of Civil Engineering and Planning Education in Universitas Negeri Yogyakarta to gain information as reference materials. The result from each university was analyzed for its strengths and weaknesses. It was followed by designing the laboratory design by referring to the results of the survey and review of existing laboratory standards. To plan the design of the building materials lab, accurate data are required, such as students' number for each class, personnel involved in the laboratory, lecture material, and other activities carried out in the laboratory. It will relate to space, layout design, equipment requirements, furniture, and supporting tools.

Based on Regulation of Minister of Research and Higher Education No.44 of 2015, laboratories must meet the requirements for space, lighting, and ventilation (Menteri Riset, Teknologi, dan Pendidikan Tinggi Republik Indonesia, 2015). It is explained in Regulation of Minister of Research and Higher Education No. 40 of 2008 that the laboratory area ranges from 4-6 m2/person. The research results from (Sandy & Cahyaka, 2014) reveal that the Building Materials Laboratory of the State University of Surabaya has an area of 4.7 m2/student. Other aspects, (Badan Standarisasi Nasional, 2001; Cleapps, 2009; Tanggoro, 2010) mention that the lightning should be at least 500 lux, the humidity is about 40-60% and the temperature of 24-27°C. With these standards, students will be comfortable during their learning activities in the laboratory. It is proven in (Yusuf, 2015) that there is an influence between non-standard lighting intensity on eye fatigue. Similarly, (Subagyo, 2017) mentions that the proper lighting system and adequate lighting intensity will cause the atmosphere of the teaching and learning process to become more convenient and enjoyable so that it can improve students learning motivation.

The layout of the building materials laboratory does not require a complex design because the activities are relatively simple, and the relationship between spaces and the activities that take place can be covered in the scope of one building. One way to determine the spatial location of the laboratory is using the Criteria Matrix as a useful technique for compacting and organizing conventional written design programs. The Criteria Matrix will show the relationship and description of each space, for example, the proximity between spaces (zone), space requirements, lighting for each room, humidity, an organizational grouping of spaces, and special considerations. The proximity among the rooms is based on the ease level of communication, supervision, and service, while lighting and humidity are based on existing standards and research results. The spaces or rooms that must be existed in the laboratory include the practice room, shop talk room, lecturer room, technician room, materials storage, and waste disposal. The building materials laboratory room is grouped into 2 zones, the main zone, and the complementary zone. The main zone is a space for student practical activities like the building material testing and concrete molding, while the complementary zone is a support room for student practical activities, such as a shop talk room, tool storage, material storage, lab coordinator room, and lecturer room and so on. The details of the building materials laboratory for 20 students with the Criteria Matrix are shown in Table 1.

Table 1: *Criteria Matrix of Building Material Laboratory for 20 Student*

Criteria Matrix of Building Materials Laboratory		*Proximity between Spaces*	*Size Requirements (m2)*	*Minimum Lighting (Lux)*	*Humidity (%)*	*Zone*
1	Shoptalk room	2,3,4	30	250	40-60	2
2	Services room	1,3,4	9	250	40-60	2
3	Lecturer transit room	1,2,4	9	250	40-60	2
4	Lab coordinator room	1,2,3,5,6	80	500	40-60	1
5	Practice testing room	4,6	6	250	40-60	2
6	Technician room	4, 5	24	250	40-60	2
7	Tool storage room	8,9,10,11,12,13,15	60	500	40-60	1
8	Concrete practice room	7,12,13		250	40-60	2
9	Concrete mold equipment room	7		250		2
10	Concrete mold room	7,11		100-200	40-60	2
11	Bathroom	7,10			40-60	2
12	Dressing room	7,8				2
13	SSD material room	7, 8			40-60	2
14	Cement material room	-			40-60	2
15	Wood material/ reinforcement room	7				2
16	Concrete soaking tub	-				2
17	Materials space for sand, gravel, brick, others	-				2

Explanation: Zone 1= main zone and Zone 2 = complementary zone

The room layout in the building materials laboratory must follow the Criteria Matrix, such as it must be side by side with the lecturer room, the shop talk room, the technician room, and the equipment storage to make sure direct supervision during students' practical activities. Then, the concrete molding practice room should be close to the storage room, concrete equipment, the molding space, and the soaking tub for the sake of efficiency and effectiveness. Also, the place for placing the test material and waste disposal should be outdoor but protected from rain and can be easily accessed for both material delivery and collection.

The tools arrangement in the building materials laboratory, especially the large one, must be placed in an accessible place for quick maintenance process. The tools placement should be in one block to assist technicians to control them. The principles in placing equipment are easy to see, easy to reach, safe, and risk-free. Around the equipment, it is given a dividing line painted in a yellow or white line of 5 cm width. The placement of furniture, such as practice tables, chairs, cupboards is arranged properly so that those do not disturb users' work activities.

To design a laboratory, it must pay attention to students' comfort in carrying out their practical activities. The research results of (Sulistyo & Hargiyarto, 2019) explain that the laboratory layout must emphasize safety, equipment placement, and OSH aspects to maintain work effectiveness. The layout plays a crucial role in increasing productivity. Several things must be considered in determining the laboratory layout including the number of students, the activities in the laboratory, the number of equipment, the convenience factor, the mobility/ access, and the ease level of practical activities. By paying attention to these aspects, the laboratory can provide satisfaction to its users.

Method

This research belongs to development research with R&D (Research and Development) approach (Gok, 2021; Mingaleva & Vukovic, 2020)two field studies for developing a survey were conducted. The first field study, pilot study, was performed for collecting the research data and making statistical analysis of the research data. After completing statistical analysis procedures (Explanatory Factor Analysis and Confirmatory Factor Analysis. The R&D is a research approach that tries to create new products or enhances existing products. The purpose of development research is to assess the changes that occur within a certain period (Daryono & Rochmadi, 2020; Pala & Erdem, 2020)whereas the How dimension comprises items expressing participation behaviors or forms. Two separate datasets were used for exploratory factor analysis (450 participants. This development model employed ADDIE (Analysis, Design, Development, Implementation, and Evaluation) which is generally used for research and development of learning models (Ezell, 2021; Yu et al., 2021)design, development, implementation, and evaluation (ADDIE. The development research from various fields can use the ADDIE model because it always follows a logical thinking process starting from analyzing, designing, or reviewing existing designs, drafting, implementing, and evaluating (Dong, 2021; Karademir et al., 2021; Trust & Pektas, 2018). The outline of the ADDIE development model can be seen in the Figure 1.

Before the development process, a situation analysis was done by making a series of questions on the objectives, the benefits, the background, and the desired outputs. This analysis stages consisted of (1) reviewing the practical content for the building materials of TEIs that hold vocational and academic study programs through discussion with the coordinators of the building materials lab from Universitas Negeri Malang, Universitas Negeri Surabaya, Universitas Negeri Medan, and Universitas Negeri Yogyakarta; (2) conducting observations in the building materials laboratory at Vocational Colledge of Universitas Gajah Mada, Undergraduate Program of Civil Engineering in Sebelas Maret University, Undergraduate Program of Civil Engineering and Planning Education in Universitas Negeri Yogyakarta to gain information as reference materials; (3) Assessing laboratory designs from various sources such as data architects, design and planning laboratories, WHO laboratory standards and so on. The design stages covered (1) collecting data related to the practical materials for the building materials and concrete technology from the four above-mentioned TEIs, (2) conducting studies and analyzing the building material laboratories of the universities, (3) analyzing and making resumes on the results of the two studies. The development stages contained (1) making a draft drawing of a laboratory floor plan, (2) making

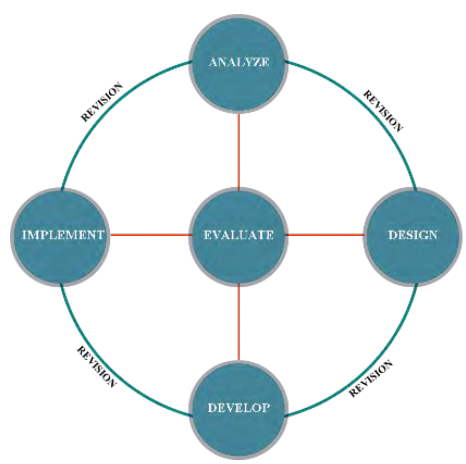


Figure 1. ADDIE Development Research Design

a list of equipment used in the building materials laboratory, (3) drafting supporting facilities of the building materials laboratory. The implementation stages included Focus Group Discussion (FGD) activities to gain the inputs related to the developed design of the building materials laboratory by inviting lecturers of building materials and lab coordinators of building materials from the TEIs, i.e. Universitas Negeri Malang, Universitas Negeri Medan, Universitas Negeri Surabaya, and Universitas Negeri Yogyakarta as well as the industry representatives, Waskita Karya, Pola Data Consultants, and Cakra Manggilingan.

The total number of FGD participants was 10 people. The materials discussed in the FGD were (a) the building materials taught at the TEIs study program for the vocational and academic program, and (b) the layout of the building materials laboratory. All inputs and feedbacks from the FGD were used to revise the design draft and the revised results were consulted to the relevant experts to achieve the applicable layout for the building materials laboratory. The evaluation stages were done through (1) the assessment from the experts related to the feasibility of laboratory layout involving the industrial parties from Waskita Karya, Pola Data Consultant, and Cakra Manggilingan; (2) The dissemination of the design through academic meetings in scientific forums as well as journals publication.

The developed layout drawing of the building materials laboratory was assessed by 2 experts in building planning from Pola Data Consultant and Cakra Manggilingan. The assessment covered two aspects, i.e. (1) the objectives of the layout description including the adequacy of space, dimensions, spaces connection, space clarity, furniture placement, placement equipment, circulation flow, accessibility, doors and windows and position, floor elevation from the laboratory; (2) the completeness aspects in communicating layout drawings including the name and scale of the drawing, size, notation, door and window openings, drawings description and clarity of layout drawings in general. The assessments covered 16 items and the score of each instrument ranged from 1 to 4 with a maximum score of 64. The results of the assessment score are then tabulated in the feasibility category as presented in Table 2.

Table 2: *Scores for the Feasibility Assessment*

No	*Range*	*Category*
1	75% <% feasibility ≤ 100%	Very Feasible
2	50% <% feasibility ≤ 75%	Feasible
3	25% <% feasibility ≤ 50%	Quite Feasible
4	0% <% feasibility ≤ 25%	Infeasible

Findings and Discussion

Based on information from the coordinators of the material building lab of Universitas Negeri Surabaya State, Universitas Negeri Medan, and Universitas Negeri Yogyakarta, the practical course of building materials included testing sand, gravel, bricks, light weight bricks, paving blocks, roof tiles, wood, reinforcing steel concrete, and mild steel, also concrete testing involved design, manufacturing, molding, maintenance and concrete test. The observation results in the building materials laboratories of the Vocational Colledge of Universitas Gajah Mada, the Undergraduate Program of Civil Engineering of Universitas Sebelas Maret, and the Undergraduate Program of Civil Engineering and Planning of Universitas Negeri Yogyakarta can be seen in Table 3 below.

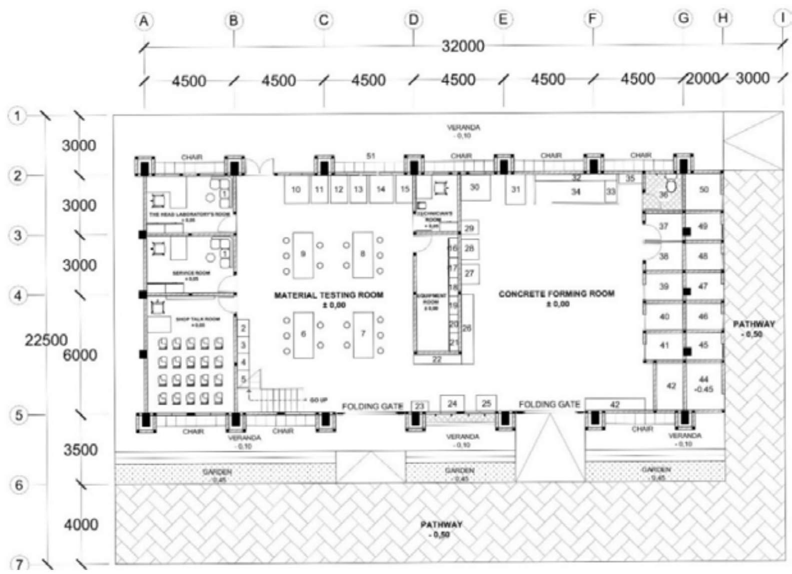
Based on the data above, of the three laboratories that have met the requirements of building material laboratory is Universitas Sebelas Maret with a total area of 138 m^2 for 40 students or 3.45 m^2 per student and the relatively large equipment space with 25.5 m^2. The building materials of this university are also completed with a concrete molding space of 36 m^2, but it is not integrated with the main lab building. Neither are the space of material storage and waste disposal that makes it quite ineffective. The shop talk room is integrated with the laboratory (not explicitly separated). Meanwhile,

Table 3.: *Observation Results in University Laboratories*

No.	*Component*	*UGM Vocational College Lab*	*UNS Civil Engineering Lab*	*UNY Civil Engineering Lab*	*Information*
1	R. Head of Lab	51 m2	12.25 m2	13.5 m2	Number of Each Class: UGM Vocational College 20 students UNS: 40 students UNY: 20 students
2	R. Technician	4 m2	4 m2	6,75 m2	
3	R. Practical	65 m2	138 m2	81 m2	
4	R. Shop Talk	-	-	27 m2	
5	R. Concrete mold	-	36 m2	-	
6	R. Equipment	10.5 m2	25.5 m2	6.75 m2	
7	Practice Room Opening Area	42.6 m2	28.8 m2	25.6	
8	Practice Room Light Intensity	133.5 lux lights off	40 lux lights off	117,4 lux lights off	
9	Humidity	49 %	66.5 %	59 %	

the building materials laboratory from Universitas Negeri Yogyakarta relatively fulfills the standard with a total area of 81 m^2 for 20 students or 4.05 m^2 for each student. The shop talk room is 27 m^2 or 1.35 m^2 per student, but the space for molding concrete does not exist where the molding process takes place in the front yard of the laboratory. The waste disposal room is near but separate from the laboratory.

Reviewing the strength and weakness of those three laboratories, the developed lab design emphasizes the following characteristics: (1) the total area that meet the existing required standard, (2) the separation between shop talk room and practice room to support discussions or technical explanations, (3) the integrated laboratory with technician room, lecturer room, coordinator room, equipment room, material storage,



Information :
1 : Guest Sofa
2-5: Concrete Table (340 x 60 x 80) cm
Oven machine (80 x 60 x 90) cm
6-9: Practicum Table (230 x 100 x 86) cm
10 : UTM bending 150 KN (100 x 86 x 140 cm)
11 : UTM Steel Tensile Test 3500 KN (51 x 45 x 175) cm
12 : UTM Controller Machine (54 x 35 x 160) cm
13 : UTM Press Concrete 1000 KN (60 x 40 x 146) cm
14 : Servo Hydraulic UTM (100 x 85 x 160) cm
15 : UTM Hydraulic Servo Controller Machine (54 x 35 x 160) cm
16- 21 : Alamri Equipment (100 x50 x 180) cm
22 : Tool Rack and Sample Test Object (240 x 50 x 180) cm
23 : Aggregate Density Test Equipment (85 x 50 x 120) cm
24 : Permeability Test Equipment (120 x 80 x 150) cm
25 : Paving Block Wear Test Kit (100 x80 x125) cm
26 : Shelf of Concrete Test Object (350 x 60 x 180) cm
27 : Gravel Sieving Machine (60 x 50 x 100) cm
28 : Sand Sieving Machine (50 x 50 x 100) cm
29 : Digital Scales (50 x 40 x 80) cm
30 : Los Angeles Machine (Equipped with Silencer) (150 x 130 x 150) cm
31 : Place Molen (150 x 100) cm
32 : Concrete Mold Place Rack (200 x 40 x 180) cm
33 : Cupboard Concrete molding equipment (96 x 40 x 175) cm
34 : Concrete Equipment Warehouse and Concrete Mold (430 x 150 x 190) cm
35 : Personal Protective Equipment Rack (120 x 50 x 190) cm
36 : Bathroom / WC (200 x 200 x 350) cm
37 : Female Dressing Room (200 x 150 x 350) cm
38 : Men's Dressing Room (200x150 x350) cm
39 : Place Cement (200 x150 x 130) cm
40 : SSD Sand Place (200 x 150 x 130) cm
41 : SSD Gravel Place (200 x150 x 130) cm
42 : Concrete Soaking Tub (250 x150 x 130) cm
43: Rack for reinforcing steel / Wood (300 x 60 x 135) cm
44 : Concrete Waste (250 x 200 x 130) cm
45 : Natural Sand Place (150 x 200 x 130) cm
46 : Natural Gravel Place (150 x 200 x 130) cm
47 : Crushed stone Place (150 x 200 x 130) cm
48 : Waste Brick / Tile (150 x 200 x 130) cm
49 : Steel / wood waste place (150 x 200 x 130) cm
50 : Other Waste (150 x 200 x 130) cm
51 : Bag lockers (350 x 50 x 150) cm

Fig. 2: Layout of the 1st Floor Building Materials Laboratory

and waste disposal area. After obtaining various inputs from the FGD results, the revised draft is presented in Figures 2 to 10.

The building materials laboratory is prepared for 20 students with a total area of 378 m2. In detail, the 1st floor is 324 m2 and 54 m2 for the 2nd floor. The height of the testing room and concrete molding room on the 1st floor is 7 meters, while the shop talk room, the service room, and the coordinator room are 3.5 meters. The area of each room is shown in Table 4. The following scores in Table 5 were obtained after the assessment.

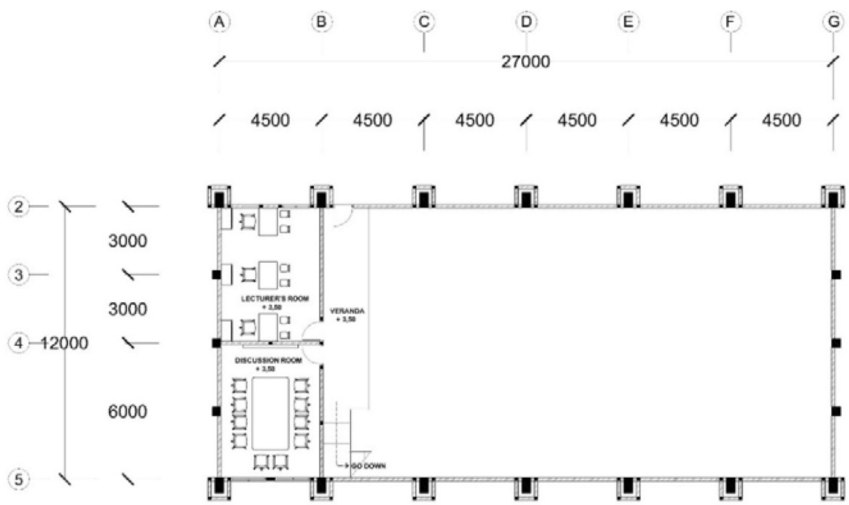


Fig. 3: Layout of the 2nd Floor Building Materials Laboratory

Fig. 4: Layout of the 1st Floor Building Materials Laboratory

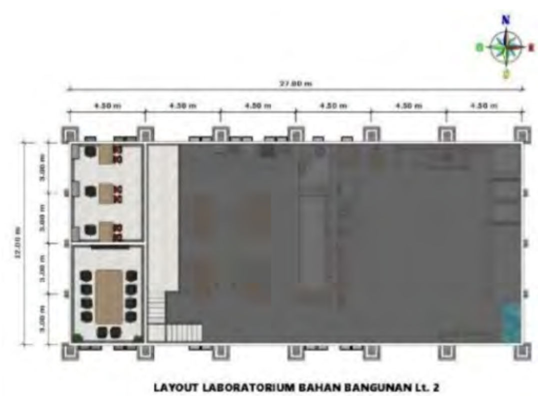


Fig. 5: 3D layout of the 2nd Floor Building Materials Laboratory

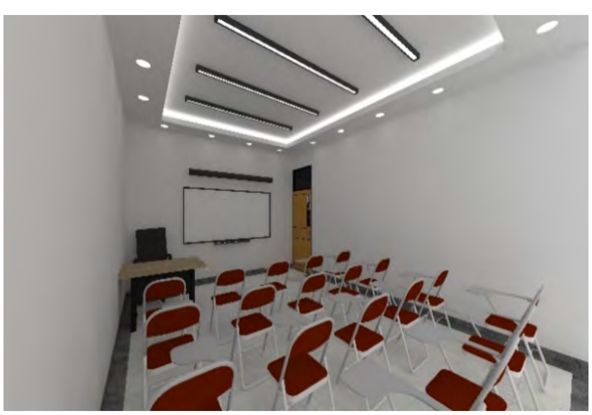


Fig. 6: Shop talk room

Fig. 7: Materials testing room

The development of higher education labs for the vocational and academic program must consider the competency analysis and the course material as well as the implementation of three pillars of higher education, i.e., education, research, and community service for this case material testing services from the construction industries. A good laboratory must integrate proper arrangement and smooth mobility. The mobility is related to easy access to material flow in the laboratory, waste disposal, and public service. The laboratory should fulfill several requirements, such as (1) the minimum room area of 4 m^2 per student (the practical room of 5.4 m^2 for each student and space for concrete molding of 4.8 m^2 per student in the layout drawing of the lab); (2) the lighting standard of 500 lux; (3) the humidity range of 50-60%. The building materials lab should be able to accommodate all activities and spaces including the practice room, the concrete molding room, the shop talk room, the lecturer room, the coordinator room, the technician room, the equipment storing room, the materials storing, the indoor concrete soaking tub, the hand & tool washing station, and the waste disposal area.

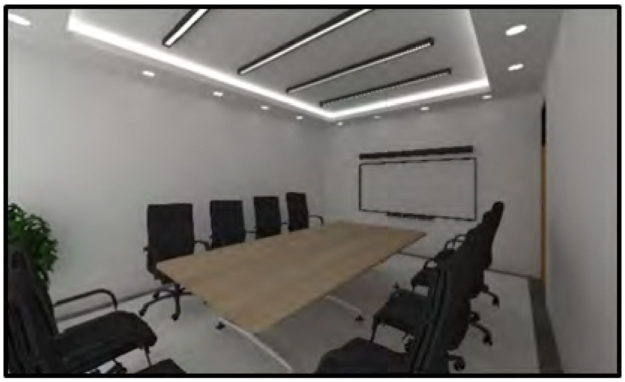


Fig. 8: 2nd floor discussion room

Fig. 9: Concrete mixing & molding room

Fig. 10: Lecturer room

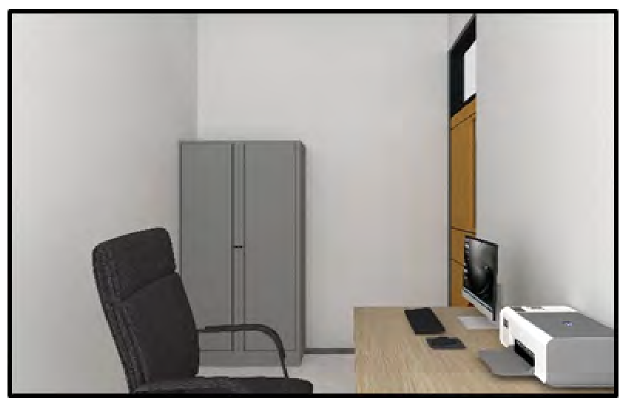


Figure 11: Technician room

Table 4: Area of Laboratory Building Materials

No	Room	Size (m^2)	No	Room	Size (m2)
1	Practical room	108	9	Concrete tool warehouse	6,4
2	Concrete molding	96	10	Male dressing room	3
3	Shop Talk	27	11	Female dressing room	3
4	Service room	13,5	12	Discussion space	27
5	Coordinator room	13,5	13	Lecturers room	27
6	Technician room	6,75	14	Material box	3
7	Equipment room	13,5	15	Concrete soaking tub	3,75
8	Toilet	4	16	Waste disposal	24

Table 5: Result of the Assessment and Feasibility Score

Assessor	*Assessment results (maximum score of 64)*	*Mean*	*Score Percentage (%)*	*Category*
Assessor 1	55	51.5	80.4	Very Feasible
Assessor 2	48			

Conclusion

The building materials lab in higher education functions as a place for practical learning activities among students of civil engineering in the vocational and academic program to support the competency mastery of building material testing. This lab is also crucial to support lecturers' research activities as well as students who are completing their final projects. The existence of this lab can enhance students' innovation, creativity, cooperation, and technical communication. The building materials laboratory can also provide public service, especially for construction industries that request to test building materials to fulfill the requirements of certain construction projects in which it can be income-generating assets to support the lab operations cost.

The development of the building material lab should be done in an integrated way to ensure cost efficiency and usability. It means that the building materials lab consisting of shop talk room, lecturer room, lab coordinator room, technician room, tool storage, material storage, concrete molding, and waste disposal area should be all integrated into one area to realize effective operation management.

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