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Analysis and diagnosis for 12 job levels of training junior civil engineers in operations and structure engineer tasks

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ABSTRACT

This study aims to determine the competencies of twelve job levels in housing construction work, as well as effective strategies to improve employee skills in each field. The method used is qualitative by conducting interviews in each competency (infrastructure, structure, landscape, mechanical, and electrical). Closed questionnaires were carried out specifically for structural engineering work, which has a greater percentage of work than other fields. Education and training, as well as demonstrations through various learning media (modules, virtual reality, and tutorials), are carried out in parallel classes through an integrated schedule that the company has prepared. The results of the study show that the standard of competency required for all fields is 448 hours for the general manager (38 hours), project manager (120 hours), assistant manager (160 hours), and supervisor (130 hours), divided into 45 subjects. An analysis of the level of knowledge and skills reports that junior structure engineers need construction work assistance and standard knowledge for building construction more than senior engineers, who have exceeded the minimum passing criteria with an average achievement of 4.23 (84%).

Keywords: job level, training, construction

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INTRODUCTION

The construction industry in Indonesia occupies the fourth position in contributing to the National Gross Domestic Product; in 2023, it is projected to absorb 8,769,798 workers (BPIW, 2022). According to (Ganet, 2022), the construction market is getting encouraged with the achievement of IDR 332.95 trillion in 2023, which consists of civil works (47.29%) and the building sector (52.71%). Civil construction will increase by 10.13 %, with a total revenue of 157.46 trillion.

Specifically, the building construction industry sector consists of four main things, as presented in Figure 1, with the urgent need for special houses having the highest achievement in 2023. This is identified with the implementation of its activities; the construction industry has involved many economic actors, including developers, contractors, workers, investors, renters,

and state financial institutions. Therefore, the focus on human resource development from the Ministry of Public Works and Public Housing regarding the construction workforce has received special attention, especially for construction worker certification (TKK) for the regular and vocational fields.

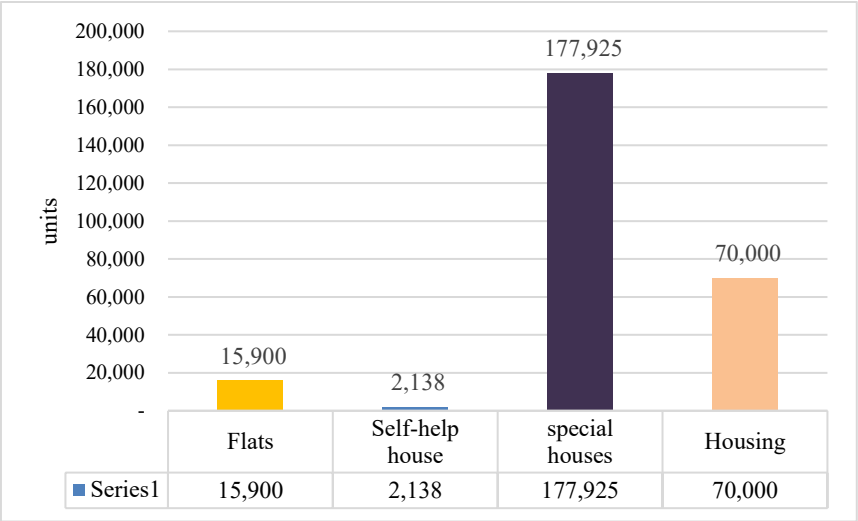

Figure 1. The main output of PUPR 2023
(BPIW, 2022)

Furthermore, a total of 46,790 TKK have been certified in Indonesia, with details of 17,800 people (academic) and 28,990 people (vocational) (LPJK, 2022). This achievement still needs to be improved, considering the main needs related to construction workers require special attention from the government. Facts on the field show that the lack of soft skills and technical capabilities is a big disaster for prospective young engineers who will venture into the world of construction (Lu & Xue, 2017); (Akinradewo et al., 2022), especially the government has enacted regulations related to Skills Competency Letters that workers in the construction sector must own and also an Engineer Registration Certificate that must be owned to protect the profession, standardize the profession, and utilize engineering practices in Indonesia.

Based on the engineering database at the Indonesian Engineers Association, out of a total of 63,371 new Bachelor of Engineering, 6.934 were registered with details of Primary (1.985), Middle (4,395), and Major (554), of which only 49.05% were officially able to carry out engineering practice. On the other hand, the construction service sector continues, and many of them still need official permits to carry out project activities. This problem is becoming increasingly complicated because they cannot meet the work qualification standards set by the government (Mostafavi et al., 2016). Apart from the absence of an official permit, It was caused by a lack of experience in solving various problems in the project. According to (Lawless, 2005) (Lawless, 2005) a shortage of experienced, uncertified, registered staff has become an obstacle to

formal legality. In this decade, the apprenticeship system implemented by the Ministry of Education and Culture has become one of the solutions offered to overcome existing competency gaps and problems and prepare good quality prospective engineering graduates so that the projected achievement targeted by the government of 265.963 building construction units this year can be carried out by local workers who have adequate requirements.

To meet the requirements, the field analysis results, which focus on multinational companies engaged in the housing sector, state that twelve main jobs are the focus of completing a building product. This means that 5.833 workers with civil expertise are currently needed to build 70,000 houses. However, big problems will arise because most of the private sector needs to be more sufficient to meet these needs. Special training is needed to increase competence in each field to create a new paradigm in which quality is the main goal of the product of the final project (Romero Barriuso et al., 2018) and (Petruneva et al., 2018).

Furthermore, in the past decade, it has been generally proposed solutions to learning problems in the industrial world (Karallis & Sandelands, 2009) through a mentoring program that can be applied at the beginning of an employee's career with very good results. Meanwhile, (Luo et al., 2021) proposed innovative talent training-based industrial teaching for tertiary institutions and the use of virtual reality to increase understanding of learning in civil engineering (Kuncoro et al., 2023), in contrast to (Kulaev et al., 2018), who reports solutions to HR problems in module-based construction, training, and entrepreneurial skills that can strengthen student leadership. However, (Guler & Mert, 2012) proposed a different approach related to internship programs in the context of sustainable human resource development, the selection of talented employees as mentoring programs (Kimberlin & Winterstein, 2008), the development of competency enhancement through gaming (Goedert & Rokooei, 2016) and (Tabassi et al., 2012) proposed the role of teamwork in the organization for solving various construction project problems. Even though on an international scale, it refers to (ABET, 2021), the minimum criteria for graduating with a degree in civil engineering must be able to cover the needs that exist in the industry today. The weaknesses of the approach are that there is no control function for each area of expertise, and there are gaps between each other because the tasks and functions need to be mapped out properly. The most fundamental value is that there needs to be an increase in skill competency to reach a professional level in the proposed program. Therefore, a new approach through field competency mapping will be combined with training and mentoring, which legally and formally refers to the output standards in the Indonesian Engineers Association and Construction Services Development Institute (LPJK) clauses. A rewards system is also proposed to be given to participants who successfully meet a certain level of competency standards in the form of an engineer registration certificate and a field expertise competency letter as a formal legal requirement to practice in the construction world.

METHOD

To understand the influence of the level of competence of experts at a certain level, this competency clustering has yet to be carried out extensively. Therefore, it is urgent to implement a qualitative method approach through field surveys in structural, infrastructure, landscape, mechanical, and electrical work (Bai & Song, 2016). It aims to provide good recommendations regarding the job mapping of junior structure engineers to intermediate skill competency levels, which require basic and core competencies ; (Zheng et al., 2019). The relevant approach is needed through several stages of observation and interviews in housing construction projects (Sahoo & Mishra, 2019). Data collection focused on the implementation of concreting work (type of material, evaluation method, planning, and implementation) and public works (scheduling, supervision); see Table 3. In contrast, the data collection tool is carried out directly (guided discussion) with experts and employees in the field.

RESULTS AND DISCUSSION

In constructing medium-level buildings, the competence of general managers, managers, assistant managers, and inspectors is required. Based on the identification and mapping of construction projects presented in Table 1.

Table 1. The results of the analysis of the competence of experts in housing

Ref Num	Position	Details	Job Description
1	General manager	-	The general manager must be able to conceive: • stages of work according to requirements. • working drawing principles and specifications. • master schedule. • problem-solving field technical problems with project construction.
2	Project manager	Infrastructure	The project manager of Infrastructure must be able to conceive: • quality of infrastructure materials. • stages of work according to requirements. • working drawing principles and specifications. • analyze the master schedule. • OSH principles. • problem-solving field technical problems related to infrastructure housing.
		Structure	The project manager of structure Engineer must be able to conceive: • structure, architect, and MEP material quality • stages of work according to procedure operational standards. • working drawing principles and specifications. • analyze the master schedule. • OSH principles • problem-solving field technical problems related to structural engineering.
		Landscape	The project manager of Landscape must be able to conceive: • quality of landscape materials • stages of work according to requirement. • working drawing principles and specifications. • analyze the master schedule. • OSH principles • problem-solving field technical problems related to landscape design.
3		Infrastructure	The assistant manager of Infrastructure must be able to:

Ref Num	Position	Details	Job Description
	Assistant Manager		• identify, understand, and analyze the quality of infrastructure materials • discover and analyze working drawings and specifications. • discover, create, and implement network planning. • identify and understand OSH principles • know and understand the function of work equipment according to project standards. • identify the National Standards (SNI). • identify and discover administration and project work reports.
		Structure	The assistant manager of structure engineering must be able to: • knowing, understanding, and analyzing the quality of Civil, Architect, and MEP materials. • discover the stages of work according to the requirement. • discover and analyze working drawings and specifications. • discover, create, and implement network planning. • identify and understand the principles of OSH Construction • identify and understand the function of work equipment according to project standards. • identify the applicable Indonesian standards (SNI). • identify and understand field administration standards and project work reports.
		Landscape	The assistant manager of Infrastructure must be able to: • identify, understand, and analyze the quality of landscape materials • and discover the stages of work according to the operational procedures. • discover and analyze working drawings and specifications. • discover, create, and implement network planning. • discover and understand OSH construction • Identify and understand the function of work equipment according to project standards. • Identify the applicable national standards (SNI). • Identify and understand administration standards and project work reports.
		Mechanical, electrical, plumbing (MEP)	The assistant manager of MEP must be able to: • Identify, understand, and analyze the material quality of the MEP Network • and discover the stages of work according to the requirement. • discover and analyze working drawings and specifications. • discover, create, and implement network planning. • identify and understand OSH construction • identify and understand the function of work equipment according to project standards. • identify the Indonesian standard (SNI). • identify and understand field administration standards and project work reports.
4	Supervisor	Infrastructure	The supervisor of infrastructure must be able to: • identify, discover and Infrastructure materials • discover and apply the stages of work according to the requirement. • read and apply DED and specifications. • identify network planning and schedule work visits. • identify, discover, and implement the OSH construction • identify, discover and apply work equipment according to project standards. • get to know the Indonesian standard (SNI). • identify, discover, and carry out field administration standards and project work reports.
		Structure	The supervisor of the structural engineer must be able to: • Identify, understand, and apply materials (civil, architectural, and MEP). • discover and apply the stages of work according to the requirement. • read and apply working drawings and specifications. • understand network planning and schedule work visits. • Identify, understand, and implement OSH construction • Identify, understand, and apply work equipment according to project standards. • get to know the Indonesian standard (SNI).

Ref Num	Position	Details	Job Description
			• Identify, understand, and carry out field administration standards and project work reports.
		Landscape	The supervisor of Landscape must be able to: • identify, understand, and apply Landscape materials • discover and apply the stages of work according to the SOP. • read and apply working drawings and specifications. • discover network planning and schedule work visits. • identify, understand, and implement OSH construction • identify, understand and apply work equipment according to project standards. • get to know the Indonesian standard (SNI). • identify, understand, and carry out field administration standards and project work reports.
		Mechanical, electrical, plumbing (MEP)	The supervisor of MEP must be able to: • know, understand, and apply MEP Network materials • discover and apply the stages of work according to the requirement. • read and apply working drawings and specifications. • discover network planning and schedule work visits. • identify, understand, and implement OSH construction • identify, understand and apply work equipment according to project standards. • identify the Indonesian standard (SNI). • Identify, understand, and carry out field administration standards and project work reports.

The competency mapping comes from fresh graduate students who need to learn about the tasks and responsibilities given by the compan (Baytiyeh & Naja, 2012); (Ramadi et al., 2016). Generally, civil engineering jobs still tend to be composed around infrastructure, so there needs to be a transfer of knowledge from the accompanying experts in the company (Itani & Srour, 2016). This requires a certain amount of time for the mentoring process, considering the great number of jobs (demands) with good quality in its implementation. Meanwhile, the level of knowledge required by each field has yet to reach these aspects. Unfortunately, due to the limited knowledge and inadequate experience, the quality of the work cannot be said to be good. Many jobs overlap, and one expert can cover other jobs, which causes inefficiency in carrying out their respective duties and responsibilities.

Furthermore, the formulation created in education and training broadly impacts the company (Ramadi et al., 2016). Investment in human resources is the main requirement for superior quality assurance and user satisfaction. The gap in the level of competence of the participants who will take part in the training compared to the existing competencies is assumed to be 100%. The next training program is prepared based on a needs analysis that follows the vision and mission of the company. The training program prepared refers to the competencies and learning outcomes, as presented in Table 2.

Table 2. The general requirement for human resources of civil engineering (construction project)

Ref Num	Training	Training hours	Courses	Subject Course	Action
1	**General manager**				Lectures, demonstrations, practice
		10	Building design	Caption design (Badir et al., 2023)	
		10	Quality Control of materials	Mechanics of materials	
		8	IT Technology in building	Building Information Modelling (Advanced) (Ma & Tao, 2023), (Hu, 2019)	
		10	Construction project management	Budget estimate plan (advanced)	
	Sub-total	38			
2	**Project manager** (Nuwan et al., 2021)				
	Infrastructure	10	Building design	Caption design (Badir et al., 2023),	Lectures, demonstrations, practice
		10	Quality Control of materials	Mechanics of materials	
		10	Building Materials and Testing	Materials technology	
		10	Construction project management	Budget estimate plan (advanced)	
	Structure	10	Construction project management	Budget estimate plan (advanced)	
		10	IT Technology in building	Building Information Modelling (Advanced) (Ma & Tao, 2023), (Hu, 2019)	
		10	Quality Control of materials	Mechanics of materials	
		10	Building Materials and Testing	Materials technology	
	Landscape	10	Landscape ecology	Introduction to landscape ecology	
		10	Landscape planning	Landscape planning	
		10	Green open space	Green open space	
		10	Planting planning	Planting planning	
	Sub-total	120			
3	**Assistant Manager**				
	Infrastructure	10	Building design	Caption design (Badir et al., 2023)	Lectures, demonstrations, practice
		10	Kendali Mutu Material	Mechanics of materials	
		10	IT Technology in building	Building Information Modelling (intermediate) (Ma & Tao, 2023), (Hu, 2019)	
		10	Construction project management	Budget estimate plan (intermediate)	
	Structure	10	Building Materials and Testing	Materials technology	
		10	Building design	Caption design	
		10	Quality control of materials	Mechanics of materials	
		10	IT Technology in building	Building Information Modelling	
	Landscape	10	Landscape ecology	Introduction to landscape ecology	
		10	Landscape analysis and design	Landscape analysis and design	
		10	Planting planning	Planting planning	
		10	Environmental Impact Analysis	Environmental Impact Analysis (basic)	
	Mechanical, electrical, plumbing	10	Plumbing installation	Plumbing for moderate building (intermediate)	
		10	Electrical installation and design	Basic Installation for Electrical	
		10	The mechanical function and space design	Mechanical for Building	

Ref Num	Training	Training hours	Courses	Subject Course	Action
		10	Occupational Safety and Health	Occupational safety and health for a construction project (intermediate)	
	Sub-total	160			
	Supervisor				
	Infrastructure	10	Construction project management	Budget estimate plan (intermediate)	Lectures, demonstrations, practice
		10	Quality control of materials	Mechanics of materials	
		10	Building design	Capstion design	
	Structure	10	Construction project management	Budget estimate plan (intermediate)	
		10	QC of materials	Mechanics of materials	
		10	Building design	Capstion design	
	Landscape	10	Environmental Impact Analysis	Environmental Impact Analysis (basic)	
		10	Planting planning	Planting planning	
		10	Landscape analysis and design	Landscape analysis and design	
	Mechanical, electrical, plumbing	10	Plumbing installation	Plumbing for moderate building (intermediate)	
		10	Electrical installation and design	Basic Installation for Electrical	
		10	The mechanical function and space design	Mechanical for Building	
		10	Occupational Safety and Health	Occupational safety and health for a construction project (intermediate)	
	Sub-total	**130**			

Identify minimum standards for construction work covering infrastructure, structure, landscape, mechanical and electrical. Table 2 shows the result of competency that must be passed and planned to obtain optimum product quality. The proposed training model relates to increasing knowledge, skills (Sahoo & Mishra, 2019), and awards for each field. The encourage integrated human resource management system model will increase the spirit of competition to learn new materials in the project. The target participants in the grand design of the development are all employees involved in the construction sector. The duration of the training is one month, and the training program will bring in accompanying instructors from UNY along with partner companies. The general material that will be taught includes (1) basic knowledge of construction; (2) codes that apply to buildings; (3) construction worker safety and health; and (4) mechanical and electrical systems for buildings.

Hereinafter, the training method will be divided into four sections, which include (1) general managers; (2) project managers; (3) assistant managers; and (4) supervisors. It aims to avoid vacancies in human resources for ongoing construction work. Meanwhile, the reward system is given to employees who have completed all training subjects and have made high achievements. The training program uses the company's curriculum, and assessments are based on standards set by companies that have collaborated with UNY. Recognition of expertise and competence is carried out by the Indonesian Engineers Association, in which each person receives

an Engineer Registration Certificate. As for field abilities, they will be included in the association according to their respective expertise at the Construction Services Development Institute. In the final stage, participants who have succeeded in obtaining the legality of the document above will be promoted to become trainers at the company and provide assistance at the intermediate and advanced levels.

Table 3. Structural engineer tasks at the housing

Ref Num	Knowledge	Skill
1	Planning, marking, and measurement	• Site organization • Reading data from the surveyor
2	Scheduling	• Organization • Timetables, gant chart, S Kurve • Daily report, weekly and monthly reports • Critical path diagram
3	Construction works	• Construction plan • QC of Materials (concrete, steel) • QC of human resources
4	Standard knowledge	• Bill of Quantity and order materials • Contract document • Work plan • Drainage

Level of knowledge and Importance degree of skills

Based on the analysis of the level of knowledge and expertise, there is a Likert scale from 1 to 5 for the average number of structural experts involved in a housing project, which is 25 (twenty-five) engineers with an average score of 3.50. This study shows that construction has significant value compared to other topics. Meanwhile, a comparison of the level of knowledge between senior and junior engineers is presented in Table 4.

Table 4. Comparison between senior and junior civil engineers

Ref Num	Planning	Scheduling	Construction works	Standard knowledge	Junior Engineers	Senior Engineers
Level of knowledge (LK)	3.20	3.15	2.8	3.13	3.07	
Importance degree of skill (IDS)	4.15	4.30	4.20	4.25		4,23

Table 4 shows that junior and senior engineers' average knowledge and skills are 3.07 and 4.23, respectively. This means that senior engineers are more dominant in restraining topics and skills in all categories (AlMunifi & Aleryani, 2019). Meanwhile, junior engineers still need mentoring programs (only 62% of skills pass) from the required standards. Companies must strengthen the construction works program, which is a weak point for junior engineers in carrying out work (Zhang et al., 2019).

CONCLUSION

Improving the quality of human resources in construction will reduce gaps in knowledge and skills that greatly impact the quality of the work. Increasing competence is mainly focused on the 12 (twelve) training subjects that each participant must pass. UNY, as one of the partners of industries, ran the program in four main parts consisting of (1) basic knowledge of construction; (2) standards or codes that apply to buildings; (3) construction worker safety and health; and (4) mechanical and electrical for buildings. Awards for participants who meet the learning achievement will be in the form of certification from the Indonesian Engineers Association (PII), engineer registration certificates, and competency certificates from LPJK, thus they can carry out engineering activities legally and formally. The contribution made in this article is that participants who have reached level one or higher will be promoted to trainers who will guide training methods in four fields.

This study has identified the need for training for experts in the field of construction through training, practice, and demonstration methods for the development of human resources following the competency of engineering. The results obtained in this study include (1) the four main project manager groups with their respective duties and responsibilities; (2) the standard minimum passing criteria that must be implemented for the completion of all education and training subjects is 448 (four hundred and forty-eight) hours with 45 (forty-five) subjects. The implication of this research is the application of integrated human resource management standards for civil engineering in construction projects, which have yet to be mapped according to their level of performance. The recommendation in this study is that the fulfillment of construction worker competency standards must refer to the engineering law, whereby every participant who practices must have an engineer registration certificate and a professional engineering certificate to ensure the sustainability of resource development and the quality of the work produced.

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