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Analysis of Design Engineering Quality Inspection on Under Ground Cable Line (UGC) 150 kV Kebon Jeruk - Duri Kosambi

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Abstract: Inspection of Engineering Products is very important to improve the quality of products and services to customers, therefore it is necessary to pay attention to the cost, quality and time of engineering and ensure that the engineering products produced meet the standards, specifications and requirements determined by the Company. The construction work of the 150 kV UGC Kebon Jeruk - Durikosambi is to improve the electricity system of DKI Jakarta and rejuvenate the UGC 150 kV Kebon Jeruk - Durikosambi and improve the quality and reliability of electricity distribution to consumers. The methods in writing this scientific journal are Measurement and Data Collection, Analysis (simulation), Evaluation and Conclusion. The cable size used is N2XCAS2Y cable measuring 1600 sqmm and a KHA value of 1002A at a depth of 13 meters. Meanwhile, at a depth of 5 meters, a KHA value of 1069A was obtained. Overall, the duration of the construction work of the 150 kV Kebon Jeruk-Durikosambi UGC is 18 months with details that can be seen in Table 4. Based on the table, if the contract ends in 2025, this work will be completed at the end of June 2027. The estimated material and construction cost (EPC) for the construction plan of the 150 kV UGC Kebon Jeruk – Durikosambi which uses a type N2XCAS2Y conductor measuring 1600 mm2 with the Horizontal Directional Drilling (HDD) method along ± 9.5 km is Rp. 34 billion/kmr. The construction of the 150 kV UGC is in the construction stage, so it is hoped that the results of the Engineering Design Concept have met the quality standards that have been set.

Keywords*: Cost, Duration, Conductor, QAQC, Standard.*

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I. INTRODUCTION

The construction work of the 150 kV Kebon Jeruk - Durikosambi High Voltage Cable Line (UGC) is to improve the DKI Jakarta electricity system and rejuvenate the 150 kV Kebon Jeruk - Durikosambi UGC and improve the quality and reliability of electricity distribution to consumers.

The Existing Condition of UGC 150 kV Durikosambi - Kebon Jeruk consists of 2 circuits that connect GI 150 kV Durikosambi with GIS 150 kV Kebon Jeruk with a length of 9 kmr. Operating in 1987, the operating age of UGC until this year has reached 36 years. UGC 150 kV Kebon Jeruk-Durikosambi is an Under Ground Cable (UGC) that uses 3x800 mm2 CU type paper and oil filled cable insulation with a nominal capacity of 720 Ampers per circuit. UGC 150 kV Kebon Jeruk - Durikosambi - circuit #2 is no longer operated due to an oil leak in the circuit #2 phasa R and T section join 6 - join 12, with an intensity of oil filling for 1 week as many as 4 times filling with a volume of 40 liters. Since December 28, 2018, UGC 150 kV Kebon Jeruk - Durikosambi circuit #1 only operates with a maximum load limited to 750 A, with one circuit with a load of up to 688A circuit due to leakage problems in crossbonding. Based on the above, to overcome the insulation oil leak, it is necessary to replace and uprate the UGC 150 kV Kebon Jeruk - Durikosambi

The construction work of the 150 kV UGC Kebon Jeruk - Durikosambi is to improve the electricity system of DKI Jakarta and rejuvenate the UGC 150 kV Kebon Jeruk - Durikosambi and improve the quality and reliability of electricity distribution to consumers.

The design, selection and measurement of UGC 150 kV Kebon Jeruk - Durikosambi equipment is influenced by many factors and conditions at the time of installation such as ambient temperature, depth, load, demand factor, percent loss of the operating period of the equipment in a state of momentary emergency overload, voltage regulation, ability

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to start large machines, load characteristics, standards used/owned by service users, and applicable international standards.

In order to follow up on the improvement of the cost, quality and time of engineering products and to ensure that the engineering products produced meet the standards, specifications and requirements determined by the Company, a QCQA Subdivision has been established for Quality Assurance (QA) and Quality Control (QC) of Engineering Products.

In the implementation of the inspection of engineering product documents from 2023 to 2024, the QAQC team has successfully inspected 190 QA products, inspections were carried out on power generation products, Network & Construction can be seen in figure 1 and while QC inspections of 475 products on generation products and Network products can be seen in figure 2.

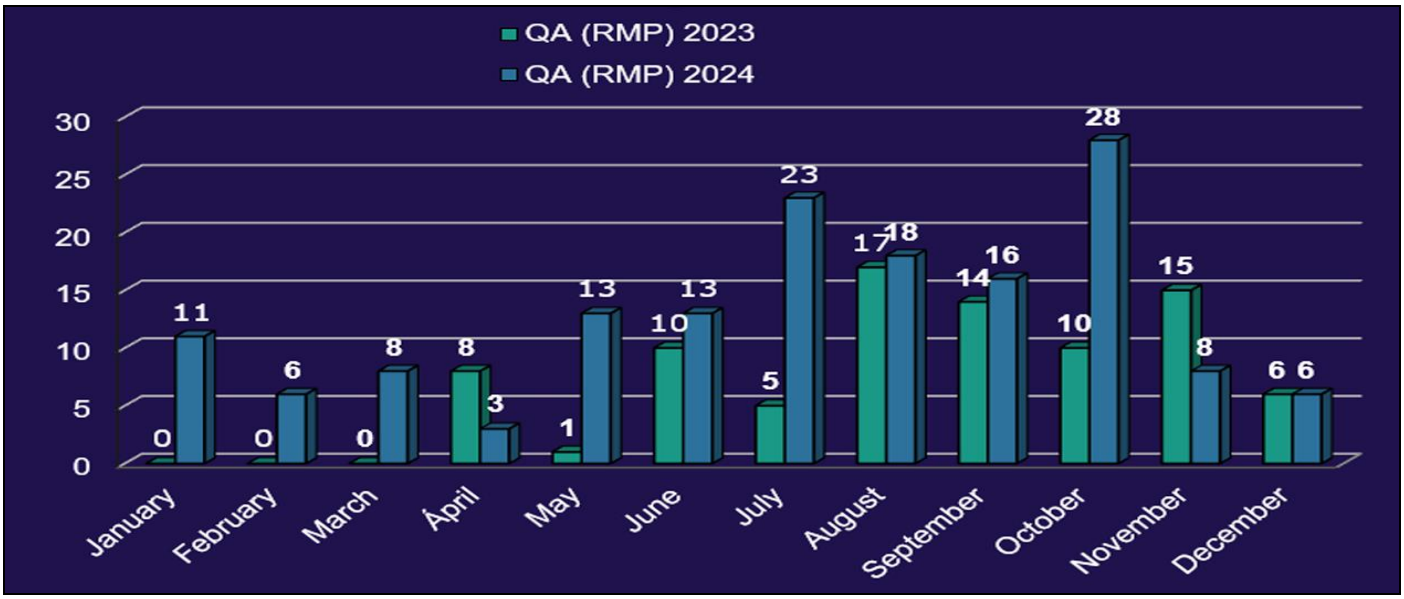

Fig 1 QA/RMP Examination Progress for 2023-2024
(Source: PLN PLNE Internal Document, 2025)

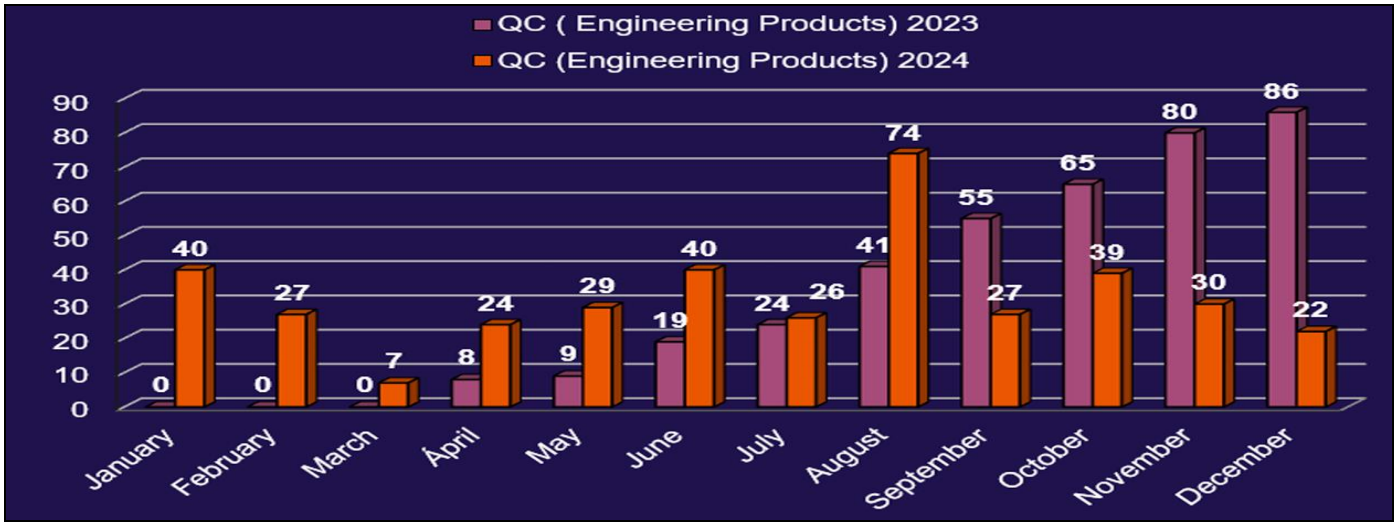

Fig 2 QC Inspection Progress in 2023-2024
(Source: PLN PLNE Internal Document, 2025)

The main task of the QA Team is to ensure and review the effectiveness of the Process at the beginning of the Work Implementation in accordance with the applicable Technical Procedures and Instructions at PLNE, based on the ISO 9001:2015 Quality Management System and/or Integrated Management System (SMT). The Project Quality Plan inspected includes Pre-Feasibility Study/Feasibility Study products, Bidding Document, Engineering Design Concept, Design Review, Construction Supervision and Engineer Estimated Price (HPE). The main task of the QC Team is to inspect the enjiniring products in accordance with the requirements of the Employer and the Enjiniring Device that applies at PT PLN Enjiniring. The products inspected include Pre-Feasibility Study /Feasibility Study products, Bidding Document, Engineering Design Concept and Engineer Estimated Price (HPE).

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II. MATERIALS AND METHODS

The materials used in this scientific journal are data taken from PT PLN Enjiniring related to the construction work of UGC 150 kV Kebon Jeruk – Duri Kosambi in the form of Design Engineering Report, QC Report for 2023-2025 and PLN Engineering Procedures for PLN Engineering: PE. PLNE. C.05.03 Procedures for Ensuring and Quality Control of Engineering Products. Scientific journal data was taken from PT PLN Enjiniring related to the construction work of the 150 kV UGC Kebon Jeruk – Duri Kosambi.

The methods in writing this scientific journal are Measurement and Data Collection, Analysis (simulation), Evaluation and Conclusion.

III. RESULTS OF DISCUSSION

In the quality inspection of PLN Enjiniring using procedures aimed at finding out that the documents to be examined are in accordance with the standards and references that have been standardized in order to ensure the quality of the product that will be delivered to the owner. The procedure is PE. PLNE. C.05.03 Procedures for Ensuring and Quality Control of Engineering Products. This procedure is prepared as a guideline in the implementation of quality assurance and control of Enjiniring products in order to meet the requirements of quality, time and cost according to the requirements of the Employer, engineering devices, and applicable regulations. This procedure regulates:

- *The mechanism for checking the planning of all projects at the Directorate of Engineering is through the examination of the Project Quality Plan (RMP) document.*
- *Implementation of the Enjiniring product inspection process, including:*

- Pre-feasibility Study, Feasibility Study
- Bid Document
- Engineering Design Concept
- Engineer's Estimated Price
- Engineering/Study

The process of preparing this Project Quality Plan can be done manually or application-based. In the process, the stages of project quality assurance and control can be shown in figure 3.

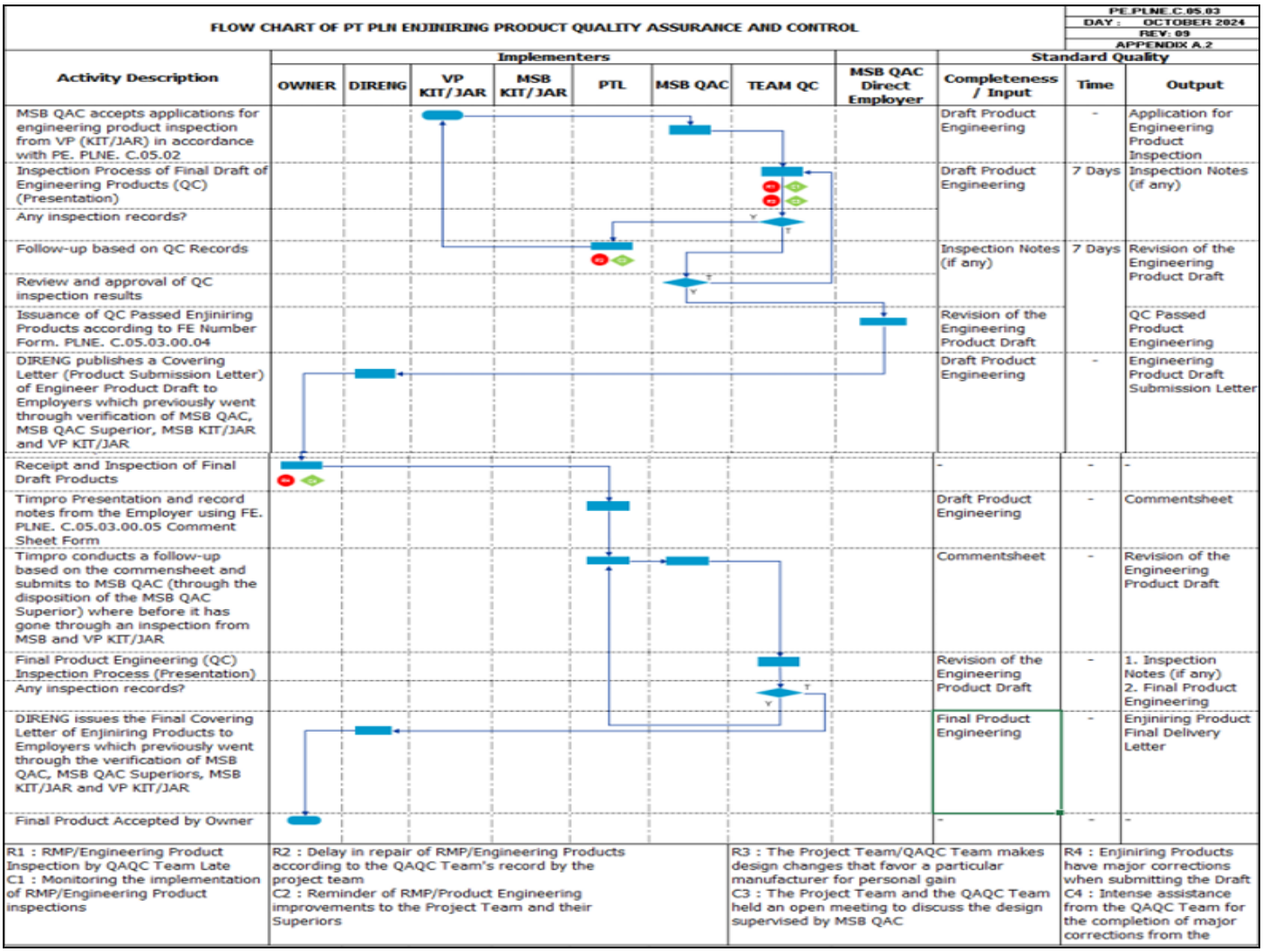

Fig 3 Product Quality Assurance and Control Flow Diagram

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➢ *Conductors Used*

The conductor used for the work of the 150 kV UGC Duri Kosambi – Kebun Jeruk in an effort to improve the electricity system of DKI Jakarta as well as rejuvenate the UGC 150 kV Kebon Jeruk - Durikosambi and improve the quality and reliability of electricity distribution to consumers. Based on the calculation of Conductive Current Strength, it is defined as the current per phase that the cable can pass continuously without exceeding the maximum temperature of the conductor. Strong Transmit Current calculated using IEC 60287. To obtain the Conductive Current Strength (KHA), calculations are made referring to the IEC 60287 series standard (for continuous loads) and IEC 60853 series (for intermittent loads, for example, service to customers for smelters). If using the manufacturer's catalog table data, it must use correction factors that are adjusted to the installation in the field.

KHA Calculation Formula:

$$I = \left[\frac{\Delta\theta - W_d \left[0{,}5\ T_1 + n\ (T_2 + T_3 + T_4)\right]}{RT_1 + nR\ (1+\lambda_1)\ T_2 + nR\ (1+\lambda_1+\lambda_2)\ (T_3+T_4)} \right]^{0{,}5}$$

Where:

ΔΘ is the allowable rise in the temperature of the conductor above the ambient temperature (K),
Wd is the dielectric loss per unit length per phase (W/m),
T1 is the thermal resistance of each core between the conductor and the sheath (K.m/W),
T2 is the thermal resistance between the sheath and the armour (K.m/W),
T3 is the thermal resistance of external serving, (K.m/W),
T4 is the thermal resistance of the medium around the cable (K.m/W),
n is the number of conductors in a cable,
v is the ratio of the thermal resistivity of dry soil and moist soil (V=ρd/ρw),
ΔΘx is the rise in critical soil temperature (K),
R is the AC resistance of the conductor at its maximum temperature (Ω/m),
λ1 is the ratio of the metallic sheath's losses to the total conductor's losses
λ2 is the ratio of Armour Taer's total loss-loss to conductor's total losses

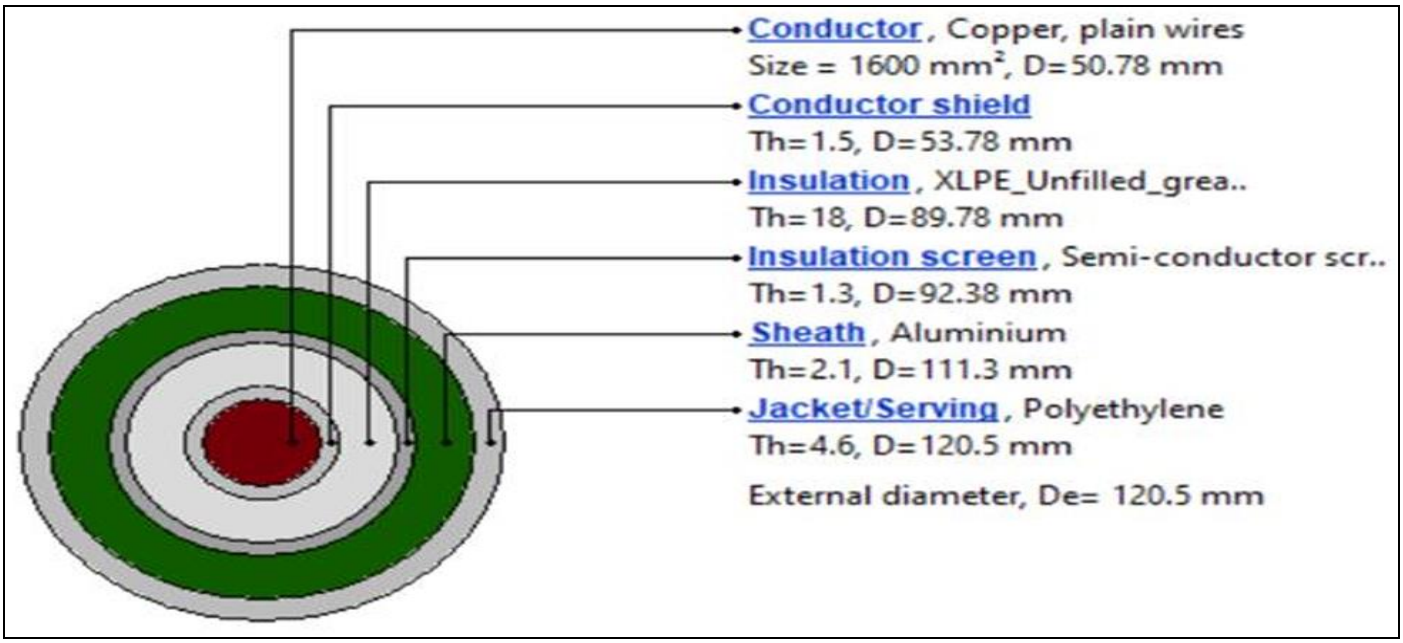

Fig 4 Cable Model N2XCAS2Y 1600 mm2
(Source: PLN PLNE internal document, 2025)

In the calculation of the power transmit current of the GI 150 kV Durikosambi - GI 150 kV Kebon Jeruk Transmission is simulated using ELEK Cable High Voltage software. The cable size used is N2XCAS2Y cable measuring 1600 sqmm and a KHA value of 1002A at a depth of 13 meters. Meanwhile, at a depth of 5 meters, a KHA value of 1069A was obtained.

➢ *Selection of Cable Deployment Methods*

The aspects to consider in choosing a cable deployment method are as follows:

- *Limitations of Field Conditions or Applicable Regulations, for Example on:*

✓ Urban areas with high traffic;
✓ National roads;
✓ Building areas with high economic value;
✓ Green land; and
✓ Other areas required by the local government.

Based on the results of the survey that has been carried out, the best path for the deployment of the 150 kV Durikosambi – Kebon Jeruk cable channel can be selected as seen in figure 5.

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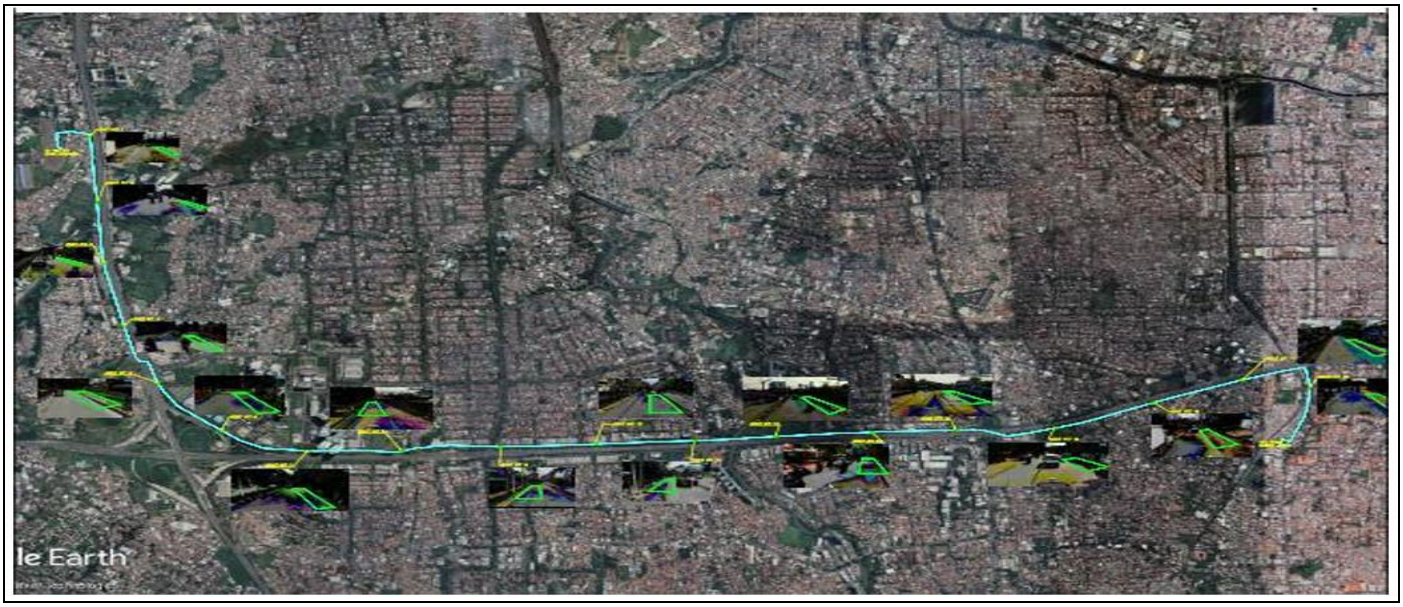

Fig 5 UGC Line 150 kV Durikosambi – Kebon Jeruk
(Source: PLN PLNE Internal Document, 2025)

Table 1 Selection of Cable Routing Method Based on Field Conditions

Field conditions	Open Cut	Boring Manual	Auger Boring	Pipe Jacking	HDD
Urban areas with high traffic	No	Yes	Yes	Yes	Yes
National Roads	No	No	No	Yes	Yes
Building areas with high economic value	No	No	No	Yes	Yes
Greenland	Yes	Yes	Yes	Yes	Yes
Other areas required by the Local Government	According to the permit granted by the local government				

- *Depth*

The selection of cable routing methods based on cable depth can be seen in the following table:

Table 2 Selection of Cable Routing Methods Based on Depth

Depth	Open Cut	Boring Manual	Auger Boring	Pipe Jacking	HDD
Shallow (≤ 3 m)	Yes	Yes	Yes	No	Yes
Medium (3 - 5 m)	No	Yes	Yes	No	Yes
Deep (> 5 m)	No	No	Yes	Yes	Yes
Note: For HDD methods at a depth of < 3 m, it is necessary to pay attention to the risk of cracking the ground surface.					

- *Crossing*

The selection of the method of making a cable route based on the type of cable route crossing can be seen in the following table:

Table 3 Selection of Cable Routing Methods Based on the Type of Crossing

Depth	Open Cut	Boring Manual	Auger Boring	Pipe Jacking	HDD	Through the Bridge
Roads Crossing	No	No	Yes	Yes	Yes	No
River Crossing	No	No	No	Yes	Yes	Yes
Note: The maximum crossing span of roads that can use the auger boring method is 25 m long						

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- *Cost*

The more sophisticated the technology used in the drilling process, the more expensive the drilling cost will be. For example, pipe jacking is more expensive than HDD. Therefore, in the selection of the cable deployment method, the most optimal method must be considered according to field conditions.

➢ *Analysis of the Duration of Work*

The duration of work for the construction of the 150 kV UGC Kebon Jeruk - Durikosambi is prepared based on several assumptions as follows:

- The preparation of administrative documents and preparatory work will be carried out after the Kick Off Meeting and will last for 2 months.
- Recheck survey and georadar activities for UGC along 9 km assuming that in one day 1 team can carry out topographic survey activities with an average distance of 3 km. By using 2 survey teams, it takes about 2 months for the recheck survey to be implemented.
- Soil investigation activities are assumed to be carried out for 2 sondir points and 2 boring points which take about 2 months using 1 team (1 sondir team and 1 boring team)
- Detailed Engineering Designed (DED) work. This work is assumed to be carried out for 3 months.
- Implementation Stage. This stage consists of:

✓ *Cable Fabrication*

Based on the length of the UGC line, it reaches 54000 m. To produce the cable material considering the production capacity of the factory of 20km/month, it takes 3 months of manufacturing process. The process of delivering materials from the manufacturer to the warehouse is estimated to be completed 1 month after the manufacturing process is completed.

✓ *Construction Stage*

For civil works consisting of foundation equipment work and joint pit work, it is assumed that it can be completed in 3 months. For electrical work that includes installation and deployment, it is estimated that 0.5kmr can be completed in 15 days, so if you use 2 HDD machines, it is expected that this work can be completed in 5 months.

✓ *Testing and Commissioning*

Testing and commissioning are the final stages of the work implementation stage. The test and commissioning consists of several stages, namely:

- *Preparation of Test and Commissioning Procedure Documents*

✓ Final check of jointing and grounding work
✓ Implementation of commissioning
✓ The implementation of commissioning consists of:

- Visual check
- Final check of all construction work completeness
- Testing system functions
- Voltage Suitability Recommendation (RLB)
- Energize
- Certificate of Fitness to Operate (SLB)

By using 1 team, it is expected that the overall testing and commissioning can be completed within 2 months.

Overall, the duration of the construction work of the 150 kV Kebon Jeruk-Durikosambi UGC is 18 months with details that can be seen in Table 4.

Table 4 Project Completion Schedule

No		Description	Duration		Year-1 Month												Year-2 Month					
					1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	1	Kick Of Meeting	1	Day	1																	
	2	Preparation of Administration and Technical Work	60	Days	1	2																
	3	Recheck Survey	60	Days			1	2														
		Soil Investigation (Sondir and Boring)	60	Days			1	2														
	4	Detail Engineering Designed (DED)																				
	a.	DED for Civil Work 150 kV	90	Days					1	2	3											
	b.	DED for Electrimechanical 150 kV	90	Days					1	2	3											
2		EXECUTION PHASE																				
	1	Cabel SKTT Fabrication	90	Days							1	2	3									
	2	Delivery material cable from factory to warehouse	30	Days										1								
	3	Construction work																				
	a.	Civil construction work																				
	-.	foundation CSE, LA, Joint Pit	90	Days									1	2	3							
	b.	Electromechanical work	150	Days												1	2	3	4	5		
	-.	Installation and laying cable																				
	4	Testing and Commissioning work	60	Days																		
	a.	Document of Test and Commissioning Procedure																			1	2
	b.	Checking jointing and grounding																			1	2
	c.	Commissioning Implementation Work:																			1	2

(Source: PLN PLNE Internal Document, 2025)

Overall, the duration of the construction work of the 150 kV Kebon Jeruk-Durikosambi UGC is 18 months with details that can be seen in Table 4. Based on the table, if the contract ends in 2025, this work will be completed at the end of June 2027.

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The estimated material and construction cost (EPC) for the construction plan of the 150 kV UGC Kebon Jeruk – Durikosambi which uses a type N2XCAS2Y conductor measuring 1600 mm2 with the Horizontal Directional Drilling (HDD) method along ± 9.5 km is Rp. 34 billion/kmr.

➢ *Quality Control Inspection*

Based on the PE procedure. PLNE. C.05.03 concerning Procedures for Ensuring and Quality Control of Engineering Products, one of which is the implementation of the Engineering Product Inspection Process is Engineering Design Concept in the examined report document, namely the 150 kV UGC Construction ED. Upon examination of documents, the QC team submits the notes in accordance with table 5.

Table 5 Project QC Inspection

No.	Chapter / Page	Notes of Findings/Suggestions	PTL Response
1	subchapter 2.2	Item 1. Route Map Explanation of cable route data provided by PLN MEP to explain what paths/roads will be passed by the cable. Which road crosses anywhere and between what road and what road, how many crossings with rivers and what rivers are to be described in this route plan. As well as how deep is the cable according to the Jakarta Governor's Decree, how many meters deep if the road and river crossings... where the depth of cable planting data will later be used in the calculation of the ability of the SKTT.	
2	subchapter 4.2	In point 4.2, the cable line must have been selected according to the information stated in subchapter 2.2 above. However, in subchapter 4.2 there is still no selection of the path that will be passed by the SKTT with each location informed of the depth of the SKTT cable planting.	
3	subchapter 3.2.2	In this subchapter, the selection of SKTT cables to 1600mm has not been shown the reason for the selection, if there is a calculation of capacity due to the depth of planting to be mentioned at this point.	
4	BoQ Sheet BOQ EM GIS AIS	Point 1.7 : Gantry Box for Optical Fiber Unit.. because SKTT uses FA cables, there is no longer a need for gantry boxes and FA cable terminations in ODF (in telecommunication rooms) Point II.2 : Optical Joint Box (JB) for FA Cable .. volume 2 (with an estimated 4,000 meters long FA cable section) Point II.3 ODF .. The volume is enough 2 sets, because the optic cable is held 1 cable.	
5	TPG	TPG 04. FIBER ARMOURED OPTICAL CABLES (FA) 48 CORE AND ACCESSORIES Point 3.3 of the requirement should be omitted and replaced with: Certificate of origin shall be submitted	
6	BOQ Civil Works	• To add Non Destructive Pile Measurement work as many as 2 locations to measure the depth of the sheet pile on both sides of the river. • Soil Resistivity to be revised to Soil Thermal Resistivity. • All quality concrete with K notation to be replaced with f'c notation according to TSS	

(Source: PLN PLNE Internal Document, 2025)

Based on the QC Team's records, the PTL (Project Team Leader) must respond to the record so that the documents made are in accordance with the standards set by regulations and employers, the response from PTL can be seen in table 6.

Table 6 Responses from PTL

No.	Chapter / Page	Notes of Findings/Suggestions	PTL Response
1	subchapter 2.2	Item 1. Route Map Explanation of cable route data provided by PLN MEP to explain what paths/roads will be passed by the cable. Which road crosses anywhere and between what road and what road, how many crossings with rivers and what rivers are to be described in this route plan. As well as how deep is the cable according to the Jakarta Governor's Decree, how many meters deep if the road and river crossings... where the depth of cable planting data will later be used in the calculation of the ability of the SKTT.	Will be corrected according to the record
2	subchapter 4.2	In point 4.2, the cable line must have been selected according to the information stated in subchapter 2.2 above. However, in subchapter 4.2 there is still no selection of the path that will be passed by the SKTT with each location informed of the depth of the SKTT cable planting.	Will be corrected according to the record
3	subchapter 3.2.2	In this subchapter, the selection of SKTT cables to 1600mm has not been shown the reason for the selection, if there is a calculation of capacity due to the depth of planting to be mentioned at this point.	Will be corrected according to the record
4	BoQ Sheet, BOQ EM GIS AIS	Point 1.7 : Gantry Box for Optical Fiber Unit.. because SKTT uses FA cables, there is no longer a need for gantry boxes and FA cable terminations in ODF (in telecommunication rooms) Point II.2 : Optical Joint Box (JB) for FA Cable .. volume 2 (with an estimated 4,000 meters long FA cable section) Point II.3 ODF .. The volume is enough 2 sets, because the optic cable is held 1 cable.	Point 1.7 akan di gunakan pada GI duri kosambi yang menggunakan AIS. Point II.2 Akan diperbaiki sesuai catatan Point II.3 ODF 1 set untuk dipasang pada GIS Kebon Jeruk.
5	TPG	TPG 04. FIBER ARMOURED OPTICAL CABLES (FA) 48 CORE AND ACCESSORIES Point 3.3 of the requirement should be omitted and replaced with: Certificate of origin shall be submitted	Will be corrected according to the record
6	BOQ Civil Works	• To add Non Destructive Pile Measurement work as many as 2 locations to measure the depth of the sheet pile on both sides of the river. • Soil Resistivity to be revised to Soil Thermal Resistivity. • All quality concrete with K notation to be replaced with f'c notation according to TSS	Will be corrected according to the record

(Source: PLN PLNE Internal Document, 2025)

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➢ *Code of Ethics for the Engineer Profession*

Professionalism is a combination of quality and behavior that characterizes the totality of a profession or a professional person A professional engineer in the implementation of work always hones his knowledge and work experience in accordance with his expertise and is guided by the code of ethics. The engineer's code of ethics is a norm and principle accepted by engineers as a foundation and behavior. The professional code of ethics not only protects society, but also builds and maintains integrity and reputation. Intelligence-based engineering is an important and respected profession that has a direct impact on the quality of human life. Therefore, the Engineering profession must be dedicated to the protection of the security, safety, health, and welfare of the Community. Engineering Practice requires honesty, impartiality, fairness, and equality and justice. Engineers are therefore obliged to be based on the principles of ethical conduct and the highest standards of integrity, which are compiled in the Engineers' Code of Conduct.

➢ *Application of K3L*

The implementation of K3L (Occupational Safety, Health, and Environment) in work consists of hazard identification (HIRARC), preparation of safe SOPs, provision of Personal Protective Equipment (PPE), routine training, and environmental risk management, aiming to protect workers from injury/disease, prevent pollution, create a healthy work environment, increase productivity, and avoid company losses.

The benefits of implementing K3L are for workers to avoid accidents and diseases, a healthy and comfortable work environment while for companies to increase productivity, reduce costs of losses, have a good company image, and avoid legal sanctions.

IV. CONCLUSIONS AND SUGGESTIONS

➢ *Conclusions*

It can be concluded that the construction of the 150 kV UGC transmission in Kebon Jeruk - Durikosambi is as follows:

- The length of the transmission line is ± 9 kmr.
- The cable uses N2XCAS2Y 87/150 (170) kV 1600 sqmm per phase.
- Based on the results of the KHA simulation with the 1600mm2 CU Cable, the CAS is 1001A for a depth of 13 meters. Communication media uses 1 x FA 48 cores.
- The rating of the short-circuit current capacity used follows the installed equipment which is 40 kA.
- Based on survey data provided by PLN, in general, the route passed by UGC is dominated by the shoulder of the highway.
- By taking into account the pollution intensity for the 150 kV UGC line Kebon Jeruk - Durikosambi, the pollution level designed for MTU is the Very Heavy level with a creepage distance of 31 mm/kV.
- The report document has been examined by the QC team, so the document has met the requirements for quality, time and cost according to the requirements of the Employer, engineering equipment, and applicable regulations.
- The construction of the 150 kV UGC is in the construction stage, so it is hoped that the results of the Engineering Design Concept have met the quality standards that have been set.

➢ *Suggestions*

- That it needs to be reviewed for the 150 kV UGC that still uses oil so that it is tried to do without using oil because it needs to be done with expensive maintance if it leaks.
- Planning for the construction of the 150 kV UGC must be mature because it must also affect the environment and society because the majority of UGC is on the environment on especially public transportation routes.

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