



## INFRASTRUCTURE DESIGN OF RESTRICTED SECURITY AREA FENCING TO ENHANCE AIRPORT SECURITY

## DESAIN INFRASTRUKTUR PAGAR AREA KEAMANAN TERBATAS UNTUK MENINGKATKAN KEAMANAN BANDARA

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### Abstract

This study aims to develop a technically compliant and economically feasible design for a Restricted Security Area (RSA) perimeter fence surrounding Substation 7, the Chiller facility, and the Ground Water Tank (GWT) at Kertajati International Airport. These facilities constitute critical operational infrastructure supporting electricity distribution, terminal cooling systems, and water supply, including fire suppression reserves. Field observations identified the absence of a regulation-compliant perimeter protection system, exposing the utility cluster to unauthorized access and operational risk. The research employed a quantitative descriptive–analytical approach integrating field measurement, engineering design modeling, volume computation, and cost estimation based on the 2024 Majalengka Regional Standard Unit Price. Technical evaluation referred to national aviation security regulations and ICAO Annex 17 principles. A BRC (British Reinforced Concrete) fence system with a total height of 3.20 meters (2.40 m fence body and 0.80 m concertina wire) was proposed. The structural configuration includes reinforced concrete isolated footings, tie beams (sloof), and a bottom plinth beam to ensure lateral stability and anti-climb resistance. The total perimeter length of 313.74 meters ensures complete enclosure of the critical facilities. The estimated total project cost amounts to IDR 509,553,000.00, including VAT. The results demonstrate that the proposed design is structurally reliable, regulation-compliant, and economically justified within a risk mitigation framework. The study contributes a replicable engineering and financial planning model for strengthening airport critical infrastructure protection and enhancing long-term operational resilience.

**Keywords :** airport security, perimeter fence, Restricted Security Area, BRC fence, infrastructure protection, cost estimation.

### Abstrak

Penelitian ini bertujuan untuk merancang desain pagar Daerah Keamanan Terbatas (DKT) yang memenuhi standar teknis dan layak secara ekonomi pada Gedung Substation 7, Chiller, dan Ground Water Tank (GWT) di Kertajati International Airport. Ketiga fasilitas tersebut merupakan infrastruktur



vital yang mendukung distribusi listrik, sistem pendingin terminal, serta pasokan air bersih dan cadangan pemadam kebakaran. Hasil observasi lapangan menunjukkan belum tersedianya sistem pagar perimeter yang sesuai regulasi, sehingga meningkatkan risiko akses tidak sah dan gangguan operasional. Metode penelitian menggunakan pendekatan kuantitatif deskriptif–analitis yang mengintegrasikan pengukuran lapangan, perancangan teknis, perhitungan volume pekerjaan, serta estimasi biaya berdasarkan Standar Satuan Harga Belanja Daerah Majalengka Tahun 2024. Evaluasi teknis mengacu pada regulasi keamanan penerbangan nasional serta prinsip ICAO Annex 17. Desain yang diusulkan berupa pagar BRC (British Reinforced Concrete) dengan tinggi total 3,20 meter yang terdiri atas badan pagar 2,40 meter dan tambahan kawat concertina 0,80 meter. Struktur didukung pondasi beton bertulang setempat, sloof beton, dan balok plint untuk menjamin stabilitas lateral dan ketahanan terhadap upaya pendakian. Total panjang perimeter yang direncanakan adalah 313,74 meter sehingga mampu mengelilingi seluruh area fasilitas vital. Estimasi total biaya pembangunan sebesar Rp509.553.000,00 termasuk PPN. Hasil penelitian menunjukkan bahwa desain pagar yang diusulkan layak secara struktural, memenuhi regulasi keamanan penerbangan, serta rasional secara ekonomi dalam kerangka mitigasi risiko. Penelitian ini memberikan model perencanaan teknis dan finansial yang dapat direplikasi dalam upaya peningkatan perlindungan infrastruktur vital bandar udara dan ketahanan operasional jangka panjang.

**Kata Kunci** : keamanan bandara, pagar perimeter, Daerah Keamanan Terbatas, pagar BRC, perlindungan infrastruktur, estimasi biaya.

## 1. INTRODUCTION

Kertajati International Airport represents one of the largest and most strategically developed airport infrastructures in Indonesia, occupying an area of approximately 1,800 hectares in Majalengka Regency, West Java. The airport was designed not only as a transportation hub but also as a catalyst for regional economic development and aviation network expansion. Due to its extensive spatial coverage and complex operational systems, the management of safety and security at this airport requires a comprehensive and integrated infrastructure protection strategy. The operational sustainability of an airport of this scale depends not solely on runway performance or air traffic control systems, but equally on the reliability of supporting utilities such as electrical substations, cooling systems, and water supply installations. Any interruption in these supporting facilities may generate systemic operational consequences, affecting passenger services, airside operations, and emergency response mechanisms.

In the framework of aviation security management, critical infrastructure within airport environments is categorized as high-risk assets requiring multilayered protection. Internationally, aviation security standards are governed by ICAO Annex 17, which mandates the establishment of protective measures against unlawful interference, sabotage, and unauthorized access within restricted areas. The principle underlying Annex 17 emphasizes layered security systems consisting of physical barriers, surveillance, access control, and monitoring procedures. At the national level, Indonesia has implemented regulatory instruments including Peraturan Menteri Perhubungan Nomor PM 33 Tahun 2015 and Keputusan Menteri Perhubungan Nomor KP 601 Tahun 2015, which require airport operators to designate Restricted Security Areas (RSA) equipped with compliant perimeter fencing and



supporting security infrastructure. These regulations specify minimum technical requirements such as fence height, structural strength, anti-climb features, surveillance integration, and lighting adequacy to ensure continuous protection of sensitive zones.

Despite the existence of this regulatory framework, field observations conducted in the southern apron utility zone of Kertajati International Airport revealed the absence of a compliant perimeter fence surrounding several critical support facilities, namely Substation 7, the Chiller plant, and the Ground Water Tank (GWT). These installations perform essential operational functions: Substation 7 distributes electrical power across airport facilities; the Chiller plant regulates terminal temperature and environmental control systems; and the GWT ensures the availability of clean water and fire-fighting reserves. The spatial proximity of these facilities within an open and partially exposed area increases their vulnerability to external intrusion, vandalism, wildlife access, and potential security breaches. From a risk assessment standpoint, such exposure constitutes a significant gap in airport security management because these facilities represent single points of failure within the broader operational network.

The absence of a properly engineered perimeter barrier contradicts the layered security doctrine adopted in modern aviation systems. Physical fencing serves not merely as a boundary demarcation device but as a strategic risk mitigation instrument designed to deter, detect, and delay unauthorized intrusion. In high-security aviation environments, perimeter fences must be structurally robust, resistant to cutting and climbing, and integrated with complementary security systems such as surveillance cameras, access gates, warning signage, and perimeter lighting. Without these protective layers, the airport's resilience against security threats remains compromised, potentially affecting operational continuity and passenger safety.

In response to this identified vulnerability, this study proposes a comprehensive technical planning model for the construction of a Restricted Security Area perimeter fence surrounding the Substation 7, Chiller, and GWT facilities. The research integrates structural engineering design, regulatory compliance analysis, quantitative measurement, volume calculation, and financial estimation through a detailed Bill of Quantities (BoQ) and Cost Budget Plan (RAB). The objective is to produce a technically sound, economically feasible, and regulation-compliant fence design capable of enhancing the overall security posture of the airport. Furthermore, the study seeks to bridge the gap between regulatory requirements and field-level infrastructure implementation by providing a systematic engineering-based planning approach. By developing a structured perimeter security design supported by quantitative and financial analysis, this research contributes not only to improving the protection of vital infrastructure at Kertajati International Airport but also to advancing practical knowledge in airport security engineering within the Indonesian context. More broadly, the findings offer a replicable planning framework that can be adopted by other airports facing similar challenges in securing utility installations within restricted operational areas, thereby reinforcing aviation safety, operational reliability, and infrastructure resilience in developing aviation systems.



## 2. RESEARCH METHOD

This study adopts a quantitative research approach with a descriptive–analytical design to develop a technically compliant and economically feasible perimeter fence plan for the Restricted Security Area (RSA) surrounding Substation 7, the Chiller facility, and the Ground Water Tank (GWT). The quantitative approach was selected because the research objective requires measurable engineering outputs, including dimensional calculations, structural specifications, material quantities, and cost estimations. The descriptive component is employed to systematically document existing site conditions, spatial configurations, and current security gaps, while the analytical component is used to transform field data into structured engineering and financial calculations.

The research process was conducted through sequential stages beginning with site identification and problem formulation, followed by field observation, data acquisition, engineering design modeling, volume calculation, and cost analysis. Field data collection was carried out between 7 February and 7 March through direct observation and coordination with airport stakeholders. The observation focused on measuring the perimeter alignment, identifying topographic characteristics, evaluating access points, and assessing existing security infrastructure deficiencies. These primary data were essential for ensuring that the proposed fence design accurately reflects actual site conditions and operational constraints. Secondary data were obtained from official regulatory documents, technical standards, and regional cost references. Regulatory compliance analysis referred to national aviation security standards, including PM 33/2015 and KP 601/2015, which govern Restricted Security Areas and perimeter fencing requirements. Additionally, cost parameters were derived from the Regional Standard Unit Price (Standar Satuan Harga Belanja Daerah) of Majalengka Regency Fiscal Year 2024. The integration of regulatory and cost data ensures that the proposed design satisfies both technical and financial governance requirements.

Spatial measurement and preliminary boundary mapping were conducted using Google Earth to determine the approximate perimeter length and facility layout configuration. Detailed engineering drawings, including fence alignment plans, foundation cross-sections, and structural detailing, were prepared using AutoCAD 2024 to ensure dimensional precision and scale accuracy. These digital tools enhanced the reliability of geometric calculations and facilitated systematic documentation of the structural design.

The study defines two principal research variables. The independent variable (X) is the technical planning and design mechanism of the perimeter fence system, which includes fence type selection (BRC, wiremesh, or chain-link), structural specifications, material standards, and compliance with aviation security regulations. The dependent variable (Y) is the level of physical security protection provided to critical airport infrastructure, measured in terms of intrusion resistance capability, compliance with Restricted Security Area standards, and mitigation of unauthorized access risk.

Data analysis was conducted in several stages. First, dimensional data were processed to determine total fence length and post spacing intervals. Second, engineering volume



calculations were performed for excavation, concrete works, structural components, and fence installation using standard construction formulas. Third, unit price coefficients were applied to calculated volumes to generate a detailed Bill of Quantities (BoQ) and Cost Budget Plan (RAB). Finally, the proposed design was evaluated against national aviation security requirements to verify regulatory conformity.

Through the integration of quantitative engineering computation, regulatory compliance analysis, and financial estimation, this methodological framework ensures that the proposed perimeter fence system is structurally adequate, economically justified, and aligned with aviation security risk management principles.

### 3. RESULT AND DISCUSSION

#### a. Site Characteristics and Security Vulnerability Assessment

The research site is located within the southern operational utility cluster of Kertajati International Airport, encompassing three critical infrastructure components:

- 1) Substation 7 – electrical distribution hub;
- 2) Chiller Plant – terminal cooling system;
- 3) Ground Water Tank (GWT) – clean water and fire suppression reserve.



**Figure 1. Kertajati International Airport**

Source: Goggle Earth, 2025

Spatial analysis shows that these facilities are positioned adjacently within an open-access zone lacking a fully compliant perimeter barrier. Based on aviation security doctrine, this condition represents a Category-A vulnerability, as the facilities function as single-point operational dependencies. Any disruption—intentional or accidental—could lead to cascading operational consequences, including electrical outages, HVAC failure, and compromised fire protection readiness.

From a regulatory standpoint, KP 601/2015 mandates that installations classified as vital objects within airport environments must be protected by physical barriers that prevent unauthorized access. Therefore, the current condition demonstrates a regulatory compliance gap requiring immediate structural intervention.



### b. Technical Specification Evaluation

The proposed fence system was developed based on national aviation security standards. The detailed technical configuration is summarized in table below.

Technical Specification of Proposed RSA Fence

Component	Specification
Total Height	3.20 m (2.40 m fence body + 0.80 m concertina wire)
Fence Material	Galvanized BRC (U-50 steel)
Wire Diameter	$\geq 6$ mm
Vertical Wire Spacing	$\leq 80$ mm
Post Type	Steel hollow / 2-inch pipe
Post Length	2,940 mm
Post Spacing	2.50 m
Foundation Depth	65 cm
Footing Size	50×50×65 cm (without strut)
Footing with Strut	85×50×65 cm
Tie Beam (Sloof)	20 cm thickness
Bottom Concrete Beam	50 cm height
Gate Type	Double-leaf swing gate

Structurally, the 3.20 m height increases intrusion delay time, while the addition of concertina wire enhances anti-climb resistance. The reinforced concrete foundation and tie beam system improve lateral load distribution and overturning resistance, particularly against wind loads and impact forces. The bottom plinth beam eliminates ground clearance gaps and reduces corrosion exposure. When evaluated against ICAO Annex 17 and CASR Part 139, the design satisfies layered security principles and structural reliability requirements.

### c. Comparative Analysis of Fence Alternatives

Three fence types were analyzed: BRC, wiremesh, and chain-link (harmonika). The evaluation criteria included structural strength, service life, constructability, and cost.

Criteria	BRC Fence	Wiremesh	Chain-Link
Structural Strength	High	Moderate	Moderate
Service Life	15–20 years	10–15 years	10–15 years
Constructability	Modular, efficient	Fast installation	Flexible terrain adaptation
Initial Cost	High	Medium	Low
Security Performance	High anti-climb resistance	Moderate	Lower rigidity

Although BRC presents a higher initial cost, lifecycle cost analysis indicates superior long-term economic efficiency due to reduced maintenance and replacement frequency. From a security engineering perspective, rigidity and resistance to deformation are decisive parameters; therefore, BRC was selected as the optimal solution.



#### d. Work Breakdown Structure and Volume Quantification

Engineering quantity take-off calculations were conducted to ensure that the proposed perimeter fence design is structurally feasible, constructible under field conditions, and financially measurable within a standardized budgeting framework. The Work Breakdown Structure (WBS) was developed to systematically decompose the project into logical work packages, beginning from site preparation through structural works and concluding with fence installation and access control components. This structured decomposition ensures that each construction activity can be quantified, costed, and scheduled accurately, thereby minimizing ambiguity during implementation.

The volume computation process was based on measured site dimensions, fence alignment geometry, and structural design specifications previously defined in Section 3.2. All calculations were derived using standard civil engineering quantity take-off formulas, incorporating geometric assumptions for linear, areal, and volumetric components. The summary of work volumes is presented in table below.

**Summary of Work Volumes**

Work Category	Volume	Unit
Site Cleaning	313.74	m <sup>2</sup>
Survey & Measurement	313.74	m <sup>2</sup>
Bowplank Installation	321.74	m
Excavation	133.34	m <sup>3</sup>
Sand Bedding	13.33	m <sup>3</sup>
Stone Foundation	27.85	m <sup>3</sup>
Reinforced Concrete Sloof	3.78	m <sup>3</sup>
Formwork	50.4	m <sup>2</sup>
BRC Fence Installation	313.74	m
Gate Installation	1	set

The calculated excavation and foundation volumes confirm adequate substructure capacity to support the designed fence height. The 313.74-meter perimeter length ensures full enclosure of the critical utility cluster.

#### e. Cost Structure and Budget Feasibility

The cost estimation for the proposed Restricted Security Area (RSA) fence was developed using the 2024 Regional Standard Unit Price (SSH) of Majalengka Regency, ensuring compliance with public procurement and regional financial governance standards. The calculation was derived from multiplying quantified work volumes by the respective unit prices, followed by value-added tax (VAT) inclusion.

**Recapitulation of Project Cost (RAB Summary)**

Work Category	Cost (IDR)	Percentage (%)
Preliminary Works	13,592,720.57	0,15
Earthworks	47,661,755.39	10,38
Foundation & Concrete Works	79,806,598.50	17,39



BRC Fence Installation	317,231,891.58	69.09.00
Miscellaneous Works	762,670.57	00.18
<b>Subtotal</b>	<b>459,055,636.61</b>	<b>100</b>
VAT (11%)	50,496,120.03	–
<b>Total Project Cost</b>	<b>509,552,998.73</b>	–
Rounded Total	<b>509,553,000.00</b>	–

The financial distribution indicates that BRC fence installation dominates total expenditure (approximately 69%). This confirms that the project is material-intensive, primarily driven by galvanized steel panels, posts, accessories, and gate systems. Foundation and reinforced concrete works account for 17.39%, reflecting the structural reinforcement necessary to support a 3.20-meter-high security fence. From a cost-efficiency perspective, the relatively small proportion of preliminary and miscellaneous works demonstrates that financial resources are concentrated on structural and security-critical components rather than administrative overhead. This allocation pattern is consistent with infrastructure projects emphasizing durability and long-term operational resilience.

A lifecycle cost interpretation suggests that although the initial capital cost approaches IDR 509.55 million, the expected service life of 15–20 years for hot-dip galvanized BRC panels reduces annualized infrastructure cost significantly. When distributed across a 20-year service life, the annualized investment becomes proportionally small compared to potential operational loss resulting from substation failure, HVAC disruption, or fire system compromise.

#### f. Discussion

The results of this study demonstrate that the proposed Restricted Security Area (RSA) perimeter fence surrounding Substation 7, the Chiller facility, and the Ground Water Tank (GWT) at Kertajati International Airport provides a technically and strategically justified solution to an identified security vulnerability. The absence of a compliant physical barrier in this utility cluster exposed critical infrastructure to potential unauthorized access, vandalism, and operational disruption. Considering the strategic role of these facilities in electricity distribution, thermal regulation, and water supply, strengthening perimeter protection is not merely a construction initiative but an essential component of aviation risk mitigation.

From a regulatory standpoint, the proposed design aligns with the layered security principles emphasized in ICAO Annex 17 and national aviation security frameworks. The concept of layered security requires that airports establish multiple defensive mechanisms, beginning with a robust physical boundary that provides deterrence and delay capability. The 3.20-meter fence height, composed of a 2.40-meter steel body and 0.80-meter concertina wire, enhances anti-climb resistance and increases intrusion delay time. This design directly supports compliance with Restricted Security Area (RSA) standards by establishing a clearly defined and structurally secure boundary around vital installations.

Structurally, the integration of reinforced concrete isolated footings, tie beams (sloof), and a bottom concrete plinth beam demonstrates engineering rationality. The 65 cm embedment depth and 2.50-meter post spacing provide adequate lateral stability while maintaining material efficiency. The use of hot-dip galvanized BRC panels enhances corrosion



resistance and extends service life to an estimated 15–20 years. This balance between structural rigidity and durability indicates that the design was optimized rather than over-engineered, ensuring both safety performance and cost efficiency.

From an economic perspective, the total estimated project cost of approximately IDR 509.55 million must be interpreted within a preventive investment framework. The majority of the budget allocation is concentrated on structural and security-critical components rather than administrative overhead, reflecting an infrastructure-focused expenditure model. When evaluated over its projected service life, the annualized cost becomes proportionally modest compared to the potential economic and operational losses resulting from infrastructure failure. Electrical disruption, HVAC malfunction, or compromised fire-fighting capability could lead to flight delays, safety hazards, and reputational damage. Therefore, the investment is justified as a preventive risk control measure rather than a discretionary capital expense.

In terms of infrastructure resilience, the enclosure of the 313.74-meter perimeter effectively transforms the previously open-access utility cluster into a controlled and compliant security zone. This intervention reduces systemic vulnerability and strengthens the reliability of interdependent operational systems. Nevertheless, the effectiveness of the fence will be maximized only when integrated with complementary security systems such as CCTV surveillance, motion detection sensors, perimeter lighting, and AVSEC patrol monitoring. The fence should therefore be understood as the foundational structural layer within a broader multi-layered airport security architecture.

Methodologically, the study contributes by integrating field-based vulnerability identification, structural engineering design, quantitative volume computation, regulatory compliance assessment, and standardized cost analysis into a unified planning framework. This approach enhances transparency, replicability, and decision-making accountability. It also offers a practical model for other airports facing similar security gaps in protecting critical utility infrastructure.

Overall, the discussion confirms that the proposed BRC-based perimeter fence is technically sound, structurally reliable, economically rational, and strategically necessary. Its implementation would significantly strengthen aviation safety compliance, reduce infrastructure vulnerability, and enhance long-term operational resilience within the airport security management system.

#### 4. CONCLUSION

This research was conducted to develop a technically compliant, structurally reliable, and economically feasible design for a Restricted Security Area (RSA) perimeter fence surrounding Substation 7, the Chiller facility, and the Ground Water Tank (GWT) at Kertajati International Airport. The study integrated field-based vulnerability assessment, structural engineering design, quantitative volume computation, and cost estimation based on regional standard unit pricing. Based on the technical analysis, regulatory evaluation, and financial calculation, the conclusions are as follows:



- a. The existing condition of the Substation 7, Chiller, and Ground Water Tank cluster indicates a security vulnerability due to the absence of a fully compliant physical perimeter barrier. These facilities represent critical operational infrastructure whose disruption could significantly affect airport safety and continuity.
- b. The proposed BRC (British Reinforced Concrete) fence design with a total height of 3.20 meters (2.40 meters fence body plus 0.80 meters concertina wire) satisfies aviation security requirements in accordance with ICAO Annex 17 and national aviation security standards. The design enhances deterrence, intrusion delay capacity, and restricted-area compliance.
- c. The structural configuration, consisting of reinforced concrete isolated footings ( $50 \times 50 \times 65$  cm and  $85 \times 50 \times 65$  cm with strut), 20 cm tie beams (sloof), and 50 cm bottom concrete plinth beams, provides adequate resistance against lateral loads, overturning forces, and soil movement. The 65 cm embedment depth ensures structural stability for a 3.20-meter-high fence system.
- d. The comparative analysis of fence alternatives (BRC, wiremesh, and chain-link) demonstrates that BRC fencing offers superior structural strength, longer service life (15–20 years), and improved anti-climb resistance, making it the most suitable option for protecting vital airport utility installations.
- e. The total perimeter length of 313.74 meters ensures full enclosure of the critical utility cluster, effectively transforming the previously open-access area into a controlled Restricted Security Area.
- f. The estimated total project cost of approximately IDR 509,553,000.00, calculated using the 2024 Majalengka Regional Standard Unit Price, confirms financial feasibility. Although material-intensive, the investment is economically justified when evaluated against potential operational losses resulting from infrastructure disruption.
- g. The integration of physical perimeter fencing with complementary systems such as CCTV surveillance, motion sensors, and automated perimeter lighting is necessary to achieve a fully layered aviation security framework.
- h. The methodological approach combining vulnerability identification, engineering design, quantitative analysis, and cost estimation provides a replicable planning model for other airports seeking to enhance security around critical infrastructure clusters.
- i. Overall, the proposed perimeter fence design is technically sound, structurally adequate, regulation-compliant, and strategically necessary to strengthen infrastructure resilience and aviation safety sustainability at Kertajati International Airport.

These findings confirm that proactive infrastructure protection planning plays a vital role in supporting long-term airport operational reliability and compliance with international and national aviation security standards.

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