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Design and Sizing of Runway Lighting Equipment at N'Dolo Airport in Kinshasa

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Abstract

The Congolese state has numerous runways, some managed by the Ministry of Transport and Communications through the Civil Aviation Authority, others by private companies, and still others, the most important, by the Civil Aviation Authority. N'Dolo Aerodrome operates only from sunrise to sunset due to a lack of runway lighting. Consequently, no aircraft can land after closing time; they must land at N'djili International Airport. For all these reasons, we are committed to conducting a study on the design and installation of runway lighting at N'Dolo Aerodrome, utilizing state-of-the-art technologies. By adopting this approach, N'Dolo Aerodrome can continue its operations 24/7 while ensuring the safety of its passengers and crew.

Keywords: Design; Sizing; Lighting and airfields

1. Introduction

Safety remains the primary priority in aviation, and reduced visibility conditions are of crucial importance in this context. Among adverse conditions, rain and poor visibility are two major factors that can lead to aborted takeoffs and landings, or even crashes that endanger the lives of passengers and crew, especially during sunset [1]. This article examines the impact of reduced visibility on takeoffs and landings, highlighting the contributing factors to these situations as well as the measures taken to improve air safety in the aerodromes of the Democratic Republic of Congo, particularly at **N'Dolo Aerodrome** in Kinshasa [2].

Our work aims to equip N'Dolo Aerodrome in Kinshasa with an adequate lighting system to address the problem of non-takeoff and/or landing after sunset. This procedure is intended to better manage reduced visibility situations and improve the safety of air operations at aerodromes in the DRC. It serves as a practical guide that we recommend electricians in the DRC use during the installation of aerodrome lighting systems.

2. Methodological Approach

2.1. Initial Data Collection

Detailed topographic surveys of the runway and its environment, meteorological records (fog, rain, wind speed), and study of air traffic movements at N'Dolo [3].

2.2. Normative Analysis

Rigorous application of ICAO Annex 14 and FAA recommendations for runway lighting, identifying critical zones requiring specific illumination.

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2.3. Lighting Layout Design

Determination of exact locations for threshold lights, centerline lights, edge lights, approach lights, and taxiway lights, with attention to redundancy and maintenance.

2.4. Photometric Simulation

Use of software to validate luminous intensity under night and degraded conditions, adjusting lighting types according to results obtained [4].

2.5. Energy Evaluation

Calculation of power requirements to ensure optimal operation and definition of backup systems best suited to local constraints, particularly in terms of electrical supply.

2.6. Current Situation

N'Dolo Airport is entirely enclosed within an urban zone, adjacent to the Higher Institute of Applied Techniques (ISTA). It is the second airport of Kinshasa and can serve as a diversion tower for specific aircraft.

Figure 1 illustrates the runway at N'Dolo Aerodrome.

Figure 1 Runway of N'Dolo Aerodrome

The airport operates only from sunrise to sunset due to the lack of lighting. Opening and closing times are established biweekly. Consequently, no aircraft can land after closing time and must instead land at **N'djili Airport**. A radio navigation aid operating at 318 MHz, located 15 m from the threshold of runway 08 NDB, has recently been reinstalled.

Table 1 Parameters of N'Dolo Aerodrome

Parameters/Results	Values/Remarks
Altitude	659 m
Temperature	32°C
Aerodrome Classification	2B
Approach Type	Visual
Runway Orientation	10/28
Runway Length	1600 m
Runway Width	30 m
Electrical Cabins	3
Generators	25 kVA

2.7. Lighting Installation Load Sizing

The load calculation of a series-circuit lighting installation can be done using graphs or mathematical calculations, with the latter being preferable [5].

Wire resistance:

$$R = \frac{\rho \times \ell}{S} \qquad \text{[eq.1]}$$

Lamp load:

P_L = W lampe x tolérances lampe = 45 x 1,08 = 48,6 W

Losses in the secondary wiring (low voltage) for S = 4 mm^2, conductor length = 2 × geometric length = 80 m.

$$R_S = \rho * 10^6 \divideontimes \frac{\text{long}}{\text{section}} \text{ en m}^2 = \frac{1{,}724.10^{-8}}{4.10^{-6}} = 0{,}3448\Omega$$

$$P_S = R_s \times I^2 = 0{,}3448 \text{ Ohm} \times (6{,}6 \divideontimes)^2 = 15, \text{W}$$

If the system uses a control and monitoring module, add 7 W.

Total losses in the secondary wiring, per set: 7 + 15.2 = 70.8 W.

Losses in the secondary circuit viewed from the primary side:

P1=P2/η=70.8/0.77=91.9 W.

Losses in the high-voltage primary and supply wiring: conductor length = 2 × (supply + primary length) = 2 × (1000 + 1600) = 5200 m.

$$R_P = \rho \divideontimes \frac{10^6 \text{long}}{\text{section}} \text{ en m}^2 = \frac{1{,}724 \times 10^{-8} \times 5200}{6 \times 10^6} = 14{,}9\ \Omega$$

$$P_S = R_s \times I^2 = 14{,}9 \text{ Ohm} \divideontimes (6{,}6\text{A})^2 = 649{,}0 \text{ W}$$

2.8. Equipment and Software Tools

2.8.1. Materials

Multi-purpose transformer lights

Combination of a specially designed 100W 6.6 A transformer and a standard elevated ADB light [6], [7]. The versatility of the construction, combined with the variety of available domes and lamp energy consumption levels, allows configurations suitable for any AGL function.

Figure 2 Multi-purpose transformer light selected for the runway of N'Dolo Aerodrome

Precision Approach Path Indicator (PAPI)

The world's only single-optical-channel PAPI provides a very distinct transition from red to white across the entire beam, with a lamp power of only 315 W.

The Precision Approach Path Indicator (PAPI) is illustrated in Figure 3 below.

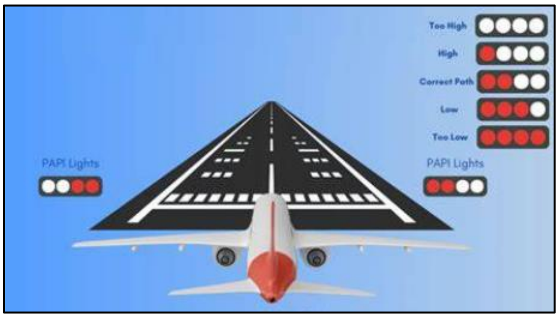

Figure 3 Precision Approach Path Indicator (PAPI)

Constant Current Regulator

A range of constant current regulators from 2.5 kVA to 30 kVA, compliant with IEC standards, was used, as shown in Figure 4.

Figure 4 Constant Current Regulator

Control System

The basic control system for airfield lighting, user-configurable. The system can operate up to 11 constant current regulators and their associated circuits.

Connections

In this case, pre-assembled connections with molded L-823 primary or secondary plugs and sockets were used, available in all lengths. They can be supplied individually or on reels for rapid deployment.

Radio Controller

The air-to-ground radio controller is used in this study to operate runway or approach lighting, as illustrated in Figure 5.

Figure 5 Air-to-ground radio controller

Backup Power Supply

To enable autonomous operation of the system and its other equipment, such as radio-controlled navigation aids, the chosen device can be supplied with power from generator units.

2.8.2. *Software*

AGi32

AGi32 is a simulation tool used to design lighting projects and calculate the amount of light to be distributed based on user-defined parameters [8], [4]. The results obtained are generally referred to as lighting plans or point-by-point lighting layouts. AGi32 can calculate the amount of light to be distributed in any type of space, indoors or outdoors, and integrate surrounding objects, obstacles, and varied shapes such as vaulted ceilings or non-linear room geometries. It assists lighting designers, engineers, and electricians in evaluating project lighting plans prior to implementation.

Figure 6 shows the interface of the lighting intensity simulation software.

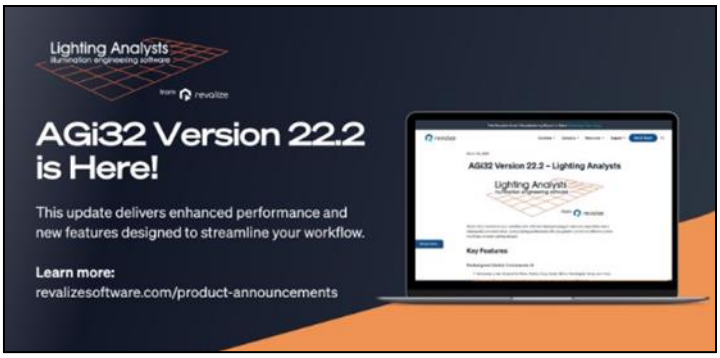

Figure 6 Interface of the lighting intensity simulation software

GIS Tools

The GIS (Geographic Information System) tool allows integration and analysis of topographic and environmental data around the runway [9].

Figure 7 shows the working interface of the geographic information system.

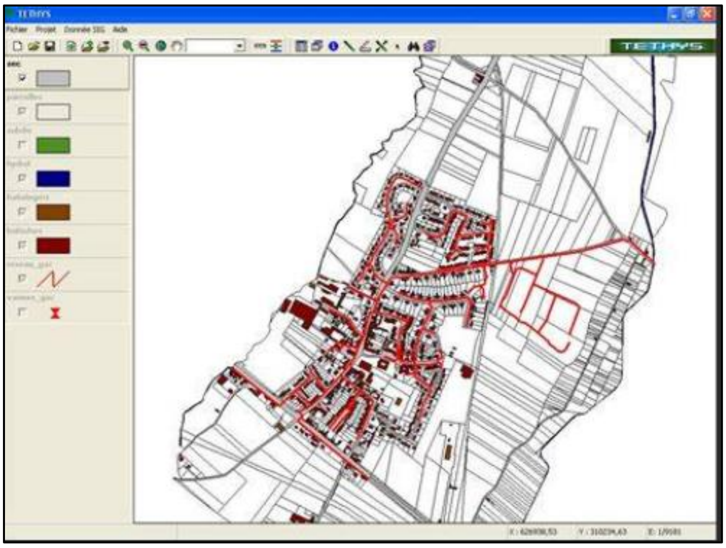

Figure 7 Working interface of the geographic information system

3. Results

The sizing process resulted in an optimal configuration of equipment:

- High-intensity LED threshold and runway end lights, positioned at each end to ensure visibility of at least 5 km.
- Centerline lights spaced at 15 meters for smooth identification of the runway center.
- Edge lights providing continuous lateral marking, ensuring a clear boundary even in the dense fog characteristic of Kinshasa.
- Brightness calibrated to meet a minimum luminous intensity of 20,000 cd (candela) for main lights, adjusted according to average meteorological conditions.
- Dual electrical system with backup batteries ensuring 4 hours of autonomy in case of power outage.
- The load calculation of a series-circuit lighting installation can be performed using graphs or mathematical calculations, with the mathematical method being preferable.

Table 2 Detailed Results for Luminaire Placement After Sizing

Parameter	**Value/Remarks**
Nominal power per light	45 W
Power tolerance per light	+8% (factor 1.08)
Current in series circuit	6.6 A
Transformer efficiency	0.77 (typical for 30/45 W transformer)
Copper resistivity	1.724×10−8 Ωm at 20°C
Control/surveillance power	7 W
Secondary wiring length	40 m
Secondary wiring section	4 mm^2
Number of lights	40
Primary wiring length	1600 m
Supply wiring distance	1000 m
Primary wiring section	6 mm^2
Supply wiring section	6 mm^2

These results strictly comply with international standards while adapting to the technical and environmental constraints specific to N'Dolo Aerodrome.

4. Discussion

The rigorous application of international standards combined with precise knowledge of local conditions demonstrates the technical and operational feasibility of the proposed lighting system. However, several challenges remain:

- Maintenance of LED equipment requires specific training for local personnel, calling for adapted training programs.
- Intermittent electrical supply in the region necessitates consideration of hybrid solutions, including future integration of solar panels to strengthen autonomy.
- Variable climatic conditions demand continuous monitoring and a real-time beacon management system to ensure optimal responsiveness in case of failure.
- A thorough economic study of installation and operating costs is essential to guarantee system sustainability.

5. Conclusion

The sizing of runway lighting equipment at N'Dolo Aerodrome in Kinshasa is part of a dynamic effort to significantly improve air safety in the DRC. By combining international normative requirements with rigorous adaptation to local specificities, this project demonstrates that effective and durable equipment is achievable. Implementing these recommendations will enable high-performance lighting, a sine qua non condition for the future development of Congolese aeronautical infrastructure. Future work should integrate training, maintenance, and continuous adaptation to technological advances.

Compliance with ethical standards

Acknowledgments

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