Architectural Localization Design Strategies for Small and Medium-Sized Terminals in Africa

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Abstract: With the ever-enhanced comprehensive national strength, China plays an increasingly important role on the international arena, and it has participated in more and more terminal projects on the African continent. By summarizing the three aspects of comparing basic parameters and technological parameters, this paper analyzes three practical projects of micromidi airport terminal buildings in Africa that were designed and constructed with Chinese participation. Finally, in the aspects of design standard, construction scale, service standard, technological process, the response of natural environment elements and the response of cultural elements, this paper compares and analyzes with the airport terminal in China. How to respond to the local cultures and realize the localization design was discussed when Chinese architecture marched into the world construction market.

1. Introduction
In the progress of internalization, China’s construction field has ranked the top of the world, and more and more construction projects designed and implemented by China have been rising abruptly from the ground of the African continent, including an enormous quantity of terminal projects. As Chinese architecture forges ahead into the world construction market, the priority should be given to the respect and response to the local regional cultures. Cabinda Airport terminal, Xai-Xai Airport Terminal and Conakry Airport terminal taken for examples, the architectural design essentials of small and medium-sized terminals in Africa were summarized, and meanwhile, their localization design strategies were discussed.

2. Design Practice Analysis and Generalization
According to different types of terminal scale, this paper selected the Cabinda Airport terminal, Xai-Xai Airport Terminal and Conakry Airport terminal as case analysis. The three airports The three airports are located in southwest Africa, southeast Africa and the West Bank of West Africa. The climate is tropical rainforest, annual average temperature is between 22 and 32. Angola's GDP per
capita was $3,432 in 2018, Mozambique's was $3,052 in 2018, and Guinea's was $724 in 2017. These three countries are the underdeveloped and the least developed areas.

2.1. Comparison of terminal profiles

2.1.1. Cabinda Airport terminal

Seated in the southwest of Africa, Cabinda Airport is located in Cabinda City, Cabinda Province, the Republic of Angola, with official language of Portuguese. The Air Traffic Control Complex Building in the newly built terminal in this phase consists of two parts: terminal and air traffic control building. The gross building area is 13,900 m², the first floor is mainly the arrival/departure functional procedure area (floor height: 6 m), the second floor is mainly the waiting area with building area of 4,814 m² and floor height of 6 m, the third floor is the control tower equipment room, and the fourth floor is the tower control room.
2.1.2. Xai-Xai Airport terminal
Mozambique Xai-Xai Airport, which is located in the southeast of Africa, is sitting in Xai-Xai City of Mozambique, with the official language of Portuguese.
The newly built terminal includes two parts: terminal and air traffic control building. The gross building area of the terminal is 3,440 m², the terminal part is on the aboveground first floor, the air traffic control part is on the aboveground second floor, and the control tower is arranged on the aboveground fourth floor. The building height is 28.5 m.

2.1.3. Conakry Airport terminal
Situated on the west bank of West Africa, Conakry Airport lies in Conakry City, the capital of Guinea, and the official language is French.
The building area of the terminal is 21,120 m², and it mainly serves international flights while considering a small number of domestic flights. The elevation of the first floor is 0.0 m, mainly being arrival/ departure functional procedure area. The height of the second floor is 12.0 m, mainly containing duty-free store and waiting area. The inter-floor elevation is 6.0 m, and it mainly provides the passenger arrival corridor, logistics management office, etc.

### Table 1: Comparison Table of Terminal Profiles

| Project name | Runway length (m) | Airfield area class | Building area (m²) | Main function | Height (m) | Configuration comparison |
|--------------|-------------------|--------------------|-------------------|---------------|------------|--------------------------|
| Cabinda      | 2,500             | 4C                 | 13,900            | Terminal+ air traffic control building+ control tower | Terminal : 16.5 | One floor and a half type |
| Xai-Xai      | 1,800             | 3C                 | 3,440             | Terminal+ air traffic control building+ control tower | Terminal: 16.5 for Control tower: 28.2 | Single-floor type |
| Conakry      | 3,300             | 4E                 | 21,120            | Terminal      | 19.10      | One floor and a half type |

2.2. Comparison of basic parameters

### Table 2: Comparison Table of Basic Parameters of the Terminals

| Project name | Class of service | Number of passengers in peak hour | Terminal type | Transfer proportion |
|--------------|------------------|----------------------------------|---------------|---------------------|
| Cabinda      | Class D          | 863                              | Domestic (serving international flights temporarily) | 10% |
| Xai-Xai      | Class D          | International 154 Domestic 154   | Domestic and international mixed flow | No transfer passengers |
| Conakry      | Class C          | 1,414                            | Centering on international flights, few domestic flights also considered | Very few transfer passengers |

2.3. Comparison of equipment parameters

### Table 3: Comparison Table of Equipment Parameters

| Project name | Check-in counters | Security check channel | Immigration office check | Customs | Hygiene inspection | Baggage reclaim belt |
|--------------|-------------------|-----------------------|--------------------------|---------|------------------|---------------------|
| Cabinda      | 14 (one large baggage check-in counter not included) | 4 | 6 | 6 | Inbound | 2 |
|              |                   |                       | Outbound | Inbound |                 |                     |
3. Terminal Design Essentials in Africa

3.1. Design standard
What is firstly faced by terminal projects in Africa is the execution problem of code standards. There are no complete airport construction standards in most of African countries, and moreover, as many of them were once colonized by European countries, the local governments require that the airport construction must refer to European standards besides the relevant standards of ICAO and IATA. For instance, Conakry Airport terminal project executes French standard and local regulations. Therefore, the designers are required to cast aside domestic design specifications, technical solutions and graphical expression they get used to, adopt European standards or American standards, and meanwhile, they have to cope with the multi-round reviews of third-party organizations.

Chinese standards have gradually gone abroad thanks to the multi-year “intensive farming” of Chinese enterprises in the architectural engineering field in Africa. Most of China-dominated terminal projects (construction aid projects and loan projects) in Africa execute Chinese standards based on the relevant regulations of International Civil Aviation Organization (ICAO), and for some individual aspects, European standards or local regulations and habits still should be executed as required by the proprietors.

3.2. Construction scale and service standard

| Airport name          | Conakry Airport terminal | Cabinda Airport | Xai-Xai Airport |
|-----------------------|--------------------------|-----------------|-----------------|
| Construction scale (㎡)| 23,980                   | 13,900          | 3,400           |
| Per capita use area (㎡)| 16.9                    | 14.4            | 9.6             |
| Service standard      | Class C                  | Class D         | Class D or E    |

Construction scale: \( A=\alpha \cdot s \)

Note: \( \alpha = \) Number of passengers in peak hour

\( s = \) Per capita use area \( (\text{Based on 《Construction Standards of civil feeder airport》 MH5023-2006 Per capita use area of domestic flight is 10~15 m}^2, \text{ Per capita use area of international flight is 20~25 m}^2)\)

Due to the undeveloped economy, few air transports have been built in Africa. The scale of urban terminals is generally within 3,000-10,000, and it may reach over 10,000 in important or economically developed cities. The terminals of over 20,000 are seldomly seen except in capitals. From the angle of industry design, the terminal scale mainly depends on the needs for number of passengers in peak hours, which is closely related to annual throughput and concentration ratio. In addition, the flight volume is very small in most cities throughout Africa, and there may even be just 2-4 flights per week in some airports, manifested by a small number of passengers and high concentration ratio. Hence, the overall terminal scale is small while the concentration ratio is high, and moreover, the functional areas
of some terminals may be mutually shared. The usage characteristics should be fully considered in the plane layout of terminals, and the functional compatibility and adjustability design should be accompanied simultaneously.

Based on the above data, it can be seen that the service standard of African airport terminals can generally reach Level D or Level C at most. This is different from the fact that nearly all domestic (Chinese) terminals can reach Level C standard, which is mainly ascribed to few flights in most of African airports, high concentration ratio, process simplification and function sharing or simplification among different terminals. The area of individual service zones is reduced in some terminals, so the usage requirement can be satisfied only with a small per capita area.

3.3. Technological process

Compared with the terminal process in China, African terminals are largely identical, but they have their own characteristics as follows: 1. Immigration office (immigration inspection) is added in the domestic terminal process; 2. Repatriation waiting room is added in the immigration inspection hall of arriving passengers; 3. In the baggage departure process, secondary inspection will be made in the baggage check-in room; 4. In Cabinda Airport, passengers are required to pick their baggage out of air-side temporary baggage storage area before boarding and load them onto the baggage cart (to avoid the situation that passengers who are waiting for the flight after security check do not board due to special circumstances).

As the social economy is underdeveloped in most African countries and many foreigners participate in the local construction, immigration office (immigration inspection) plays an important role that facilitates the local social security and management. Hence, the immigration inspection is added to both international and domestic terminal processes, and the customs inspection upon arrival mainly aims at checking whether prohibited goods are contained in the foreigners’ baggage.

Therefore, the processes of immigration office and custom inspection and related function rooms should be taken into account in the plane layout design of terminals of this kind, e.g. whether to include the functions like queuing space, inspection channel, check and repatriation.

3.4. Design of process facilities

Because of the differences in national conditions and using habits, the process design and calculation of terminals in Africa are slightly different from domestic (Chinese) terminals, and hereby Cabinda Airport terminal is taken for example.

3.4.1. Quantity calculation of check-in counters (centralization)

\[
N = \left( \frac{(a + b) \cdot 60\% \cdot t}{30} \right) \cdot 1.1
\]

Note: a= departure passengers;
b= transfer passengers in lining up for check-in;
t= average ticket exchange time per passenger=1.8 min;

According to the operating habits of Angola airports, artificial check-in is adopted for 100% passengers.

Without the statistical data of transfer passengers, the number of transfer passengers is small as speculated according to the geographical location and current situation of Cabinda, so the proportion is ignored.

Calculation result: \( N = (432 \times 0.8 + 0) \times 0.60 \times 1.8 \times 1.1 / 30 \approx 14 \)

3.4.2. Quantity calculation of safe passages

\[
N = \left( \frac{(a + b) \cdot 60\% \cdot w}{\gamma \times (30 / 60)} \right) \cdot 1.1
\]

Note: a=departure passengers;
b = transfer passengers;  
w = number of hand baggage per passenger;  
y = average check efficiency of each X machine.

In consideration of understaffed operations management and common idle status of facilities in Cabinda Airport, the minimum value is taken for the calculation of facilities and equipment.

A specialized president terminal is built in Cabinda Airport, the VIP departure lounge in the newly built terminal is specialized for revenue passengers, the process facilities here are included into process facilities of ordinary passengers, and no independent calculation is needed.

Calculation result: \[ N = \frac{(432+0) \times 0.60}{120 \times \left(\frac{30}{60}\right)} \approx 4 \]

During the concrete design process, the index values should be adjusted within a certain range according to the terminal scale, service class and local terminal operating habits.

### 3.5. Response to natural environmental factors

African areas have high-temperature and rainy climatic features. Therefore, the attention should be paid to sun-shading system, ventilation system design of buildings in the terminal design.

**Table 5: Summary of sun-shading systems**

| Project name | Countermeasures of sun-shading system | Graphical representation |
|--------------|--------------------------------------|--------------------------|
| Cabinda      | Main façade: deep cornice + sun-shading glass curtain wall, lateral façade: solid wall + sun shield, lateral high window at the roof side can avoid direct exposure to sunlight | ![Graphic of Cabinda sun-shading system] |
| Xai-Xai      | Main façade: sun-shading canopy beside lanes + double-layer curtain wall, lateral façade: solid wall + sun-shading curtain wall formed by metal gratings | ![Graphic of Xai-Xai sun-shading system] |
| Conakry      | Sun-shading canopy beside lanes + deep cornice + Glass curtain wall formed by metal plates + inward inclination of glass wall + inward inclination of lateral roof skylight | ![Graphic of Conakry sun-shading system] |

**Table 6: Summary of ventilation systems**

| Project name | Countermeasures of ventilation system | Graphical representation |
|--------------|--------------------------------------|--------------------------|
| Cabinda      | Main façade: deep cornice + sun-shading glass curtain wall, lateral façade: solid wall + sun shield | ![Graphic of Cabinda ventilation system] |
3.6. Response to cultural factors

Building is an important means and medium that depicts the history and inherits the pulse of culture. Besides the functional role as a transportation hub, a terminal also serves as the portal of its city and even country. Therefore, it is especially important to embody the context characteristics in the architectural modeling design.

In Conakry Airport terminal, the elements of local braided crafts are extracted and applied to the glass curtain wall, and the proportion of transparent part and untransparent part of the glass curtain wall is adjusted according to the demand for indoor light environment. The reddle color of local red soil is selected for decorative columns, curtain wall framework and main indoor ceilings. The color of red soil is also adopted in Cabinda Airport terminal. Its vermilion curtain wall formed by aluminum plates, and glass curtain wall together form an intense virtual-real comparison, embodying the era characteristics of modern aviation buildings. As for Xai-Xai Airport terminal, the motif is extracted from the prototype—diamond that the local area is abound in. The canopy beside the lanes, glass curtain wall and glass curtain wall in the tower control room are all spliced by triangles in multiple faces, thus forming a terminal image of unique local style.

The selection of building materials stands for the local geographical features. Because of the local differences in production technologies of building materials and practical building construction in Africa, many building materials need to be directly transported to the construction site from home, and this type of resource acquisition leads to a higher cost. Therefore, the building materials in the local market should be deeply investigated, and the local mature building materials and construction technologies should be used as alternatives as far as possible based on the feasibility research.

Through an exploration into artistic patterns, local colors, shape metaphors, ethnic cultures, local materials etc., the cultural factors are blended into the design of the three projects so that the buildings can be rooted in the African continent and win the cultural identity of local people.

4. Conclusion

As Chinese architecture goes world, a modest attitude should be held, respecting the natural environment and humanistic environment of target country. On the one hand, a terminal, which is the core building in an airport, is constructed to satisfy the air shipping needs and realize smooth and efficient streamlined operation, and on the other hand, it represents the image of a city and a region, and undertakes the mission of cultural building. When it comes to small and medium-sized terminal design in Africa, the reasonable terminal design standard, construction scale and service standard, technological process and parameters of process facilities and equipment should be firstly determined according to the local historical and political characteristics and economic and technical conditions. Meanwhile, efforts should be made to respond to the high-temperature and rainy natural environment.
through the reasonable design of sun-shading system and ventilation system. Based on the exploration into artistic patterns, local colors, shape metaphors, ethnic cultures, etc., the cultural factors are blended into the design of the three projects, and a terminal that can be truly rooted in the African continent can be created through the six abovementioned responses, thus providing a certain reference for the future construction of small and medium-sized terminals in Africa.

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