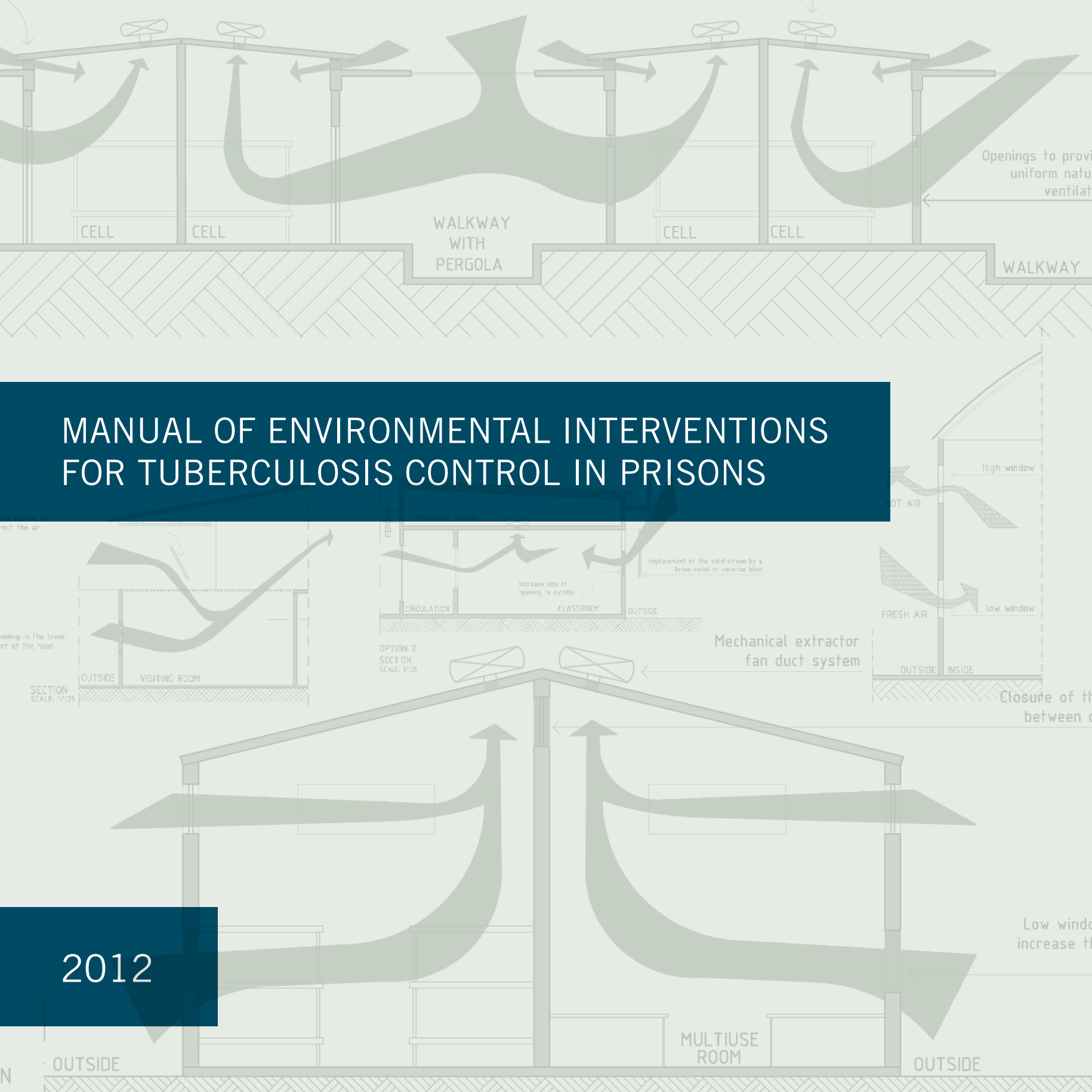
MANUAL OF ENVIRONMENTAL INTERVENTIONS FOR TUBERCULOSIS CONTROL IN PRISONS



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Contents

Foreword

Tuberculosis is known to be transmitted from person-to-person through the air and to be particularly frequent in prison environments due, above all, to the absence of adequate ventilation and sunlight, as well as overcrowding. However, the strategies adopted to control TB in these environments continue to be essentially biomedical (identification and treatment of cases) and educational. These measures remain, without doubt, the priority, but their effectiveness is limited if they are not associated with measures aimed at improving environmental conditions, rarely implemented. Presenting solutions for improving the environmental conditions to safeguard the health of those frequenting the prison environment without compromising security is one of the challenges of this manual.

Developed by the Faculty of Architecture and Urbanism of the Federal University of Rio de Janeiro (FAU-UFRJ), the Global Fund Project and the Penitentiary Department (DEPEN), with the participation of the National TB Control Program (PNCT/MS), the present manual is not an architectural exposition. Using a language comprehensible to non-specialists, its aim is to propose, based on concrete examples, simple low-cost interventions for improving the ventilation and natural lighting in prisons.

To meet this goal, it is essential to involve all actors whose combined effortsare required for the planning and implementation of these interventions: architects, engineers, those responsible for health and security in the prisons, civil society organizations involved in social monitoring of prisons, representatives of the Public Prosecutor's Office and judges in charge of sentence application. These actors have contributed to the elaboration of this manual through their participation in regional workshops.

This manual has been written in an accessible language and contains numerous illustrations. After recalling the important role played by environmental factors in the high frequency of TB in prisons, the authors examines a number of aspects of DEPEN's current architectural guidelines for the construction and reformation of prisons and present basic notions concerning ventilation and lighting, as well as suggestions for interventions to improve them.

However the essential part of this manual is found in the chapter 'Projects and interventions,' which contains an architectural study of ventilation and lighting based on old and recent prison plans from different regions of the country. The study identifies negative and positive aspects and explores proposals for intervening to improve environmental conditions. The next chapter, dedicated to examples of "Good practices" and illustrated by photos and plans, refers to specific solutions that the authors consider particularly interesting, implemented in prisons from various states of Brazil.

A bibliography is provided for those desiring more in-depth information on the theme, as well as a glossary where the technical terms are explained. A form for evaluation of environmental conditions for the control of tuberculosis in penitentiary establishments is also provided to help actors who ensure the execution of prison sentences and its social control to perform their mission when they perform evaluation visits to the prisons.

Hence, this manual provides the technical grounds for the different actors responsible for both the monitoring and execution of penal sentences to contribute in the reduction of the intra-institutional transmission of TB and other respiratory diseases by improving the ventilation and natural lighting conditions in prisons.

This approach may be useful as well to the many countries where the conditions of incarceration are inadequate.

Introduction

NEED FOR ENVIRONMENTAL INTERVENTIONS TO CONTROL TUBERCULOSIS IN PRISONS

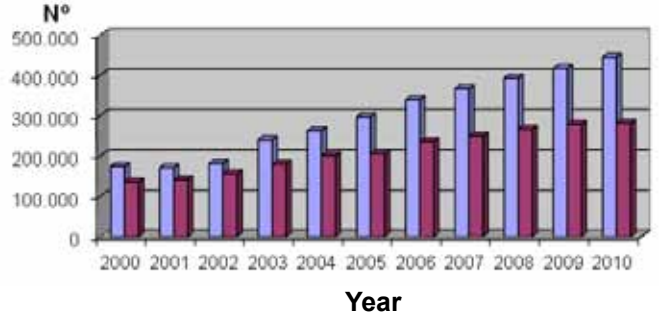
Tuberculosis and other respiratory infections are transmitted from person-to-person through the air expired from sick individuals. Consequently, proximity to an infected person plays an important role in the transmission of these diseases, along with the absence of ventilation which allows infectious particles eliminated by sick individuals to remain suspended in the ambient air and become inhaled by contact subjects. Additionally, the persistence of infectious elements in the environment is favoured by the absence of natural lighting, since sunlight has a bactericidal effect.[1]

For these reasons, **overcrowded, poorly ventilated and badly sunlit environments** – as observed in the majority of prisons, public jails and police stations where around 494,237 people deprived of liberty (PDLs) live in Brazil[2] – are particularly favourable to the spread of respiratory diseases, especially tuberculosis. Results from molecular epidemiological studies conducted in Rio de Janeiro's prisons have shown that in prisons with high endemicity, around 75% of the identified tuberculosis cases were related to recent infections, presumably acquired in prison.[3]

This data suggests that **mass circulation of strains of the tuberculosis bacillus** plays an important role in maintaining the high frequency of the disease observed among PDLs, demonstrating the need for urgent interventions to improve the ventilation and lighting conditions as a complement to the basic strategy of detecting and treating cases. Very few prisons exist where the communal areas used by PDLs (schools, canteens, churches, workshops, etc.), health services and area reserved to prison officers have adequate ventilation and lighting. Health requirement are frequently sacrificed in the name of security requirements.

Overcrowding in prison units has worsened in Brazil over recent years with a growing disproportion between the increase in the number of prisoners (154% between 2000 and 2010) compared to the increase in places (107%), as shown in Graph 1. Over the same period, the shortfall in capacity has risen from 39,270 to 164,624.[3]

Graph 1. Evolution in Brazil of the prison population (blue) versus capacity (red)



Cells are still collective in most prison units, in some cases with a population over 60 prisoners, in contravention to national[4,5] and international[6] recommendations, which limit the number of PDLs as a ratio of available surface area. According to Resolution Nº 09/11 of the National Council for Criminal and Penitentiary Policy (CNPCP),[5] individual cells should have a minimum area of 6m^2, and collective cells a maximum capacity of eight inmates with a minimum area of 13.85m^2, and volume of 34.60m^3.

For these reasons, the **annual frequency of new tuberculosis cases in prisons (incidence rate) is very high,**[7-9] **in some states as**

much as 38 times the rate of the population as a whole. Epidemiological surveys conducted in three prison units in Rio de Janeiro, with a total of 3,014 PDLs studied, showed that the frequency of TB in these units was 4.6%, 6.3% 8.6%, and around 2% for HIV infection.[10,11] Among the 1,698 individuals who had entered the penitentiary system, the frequency of TB was 2.7%,[12] which can be associated with the particularly bad incarceration conditions during police custody.

A similar study carried out in Porto Alegre showed that one in ten PDLs (10%) presented active tuberculosis while one in twenty had been infected by HIV (5%).[13] These high rates were also observed in the states of Bahia[14] and São Paulo.[15] In addition to prison conditions and overcrowding, **other factors contribute to the high frequency of tuberculosis in prisons**: the high rate of HIV infection, use of drugs, inadequate and difficult to access healthcare, and the high frequency of previous imprisonment and previous treatment for tuberculosis, which implies a higher likelihood of contracting resistant forms of infection due to incomplete treatment.[16]

Since transmission of the tuberculosis bacillus occurs through strains exhaled by sick persons which remain airborne for variable periods,[1] one of the basic measures for avoiding contagion is to improve air circulation. In addition the bacillus presents little resistance to the ultraviolet radiation present in sunlight, which makes natural lighting a powerful ally in the control of the disease. Poor air renewal and lack of sunlight affect the healthiness of the environment, favouring the occurrence of TB, and other respiratory infections. Depending on the local climate, the situation can become worse, as in regions with high air humidity and little wind.

These measures will contribute to reducing the intra-institutional transmission of respiratory infections, especially tuberculosis, **benefitting not only PDLs and their contacts** (relatives, visitors, guards, healthcare professionals and other people frequenting the prisons), but also the wider community into which convicts will return on release.[17]

Mass circulation of TB strains in highly endemic prisons suggests that the effectiveness of biomedical strategies (involving the identification and treatment of cases), which form the basis of TB control strategies, may be limited by failing to associate them with

The purpose of this manual is to propose architectural solutions for improving natural lighting and ventilation conditions which, respecting security requirements, can be incorporated in the construction of new prisons and the renovation of existing units.

reductions in prison overcrowding and interventions designed to improve ventilation and natural lighting in the prison units.[3] **These interventions, which do not necessarily imply high additional costs, should be included in the set of strategies for controlling tuberculosis in prisons**.[18]

For security reasons, windows and other types of openings are avoided inside cells and other area occupied by inmates in order to prevent escapes or even communication between occupants. As a consequence, air circulation and natural lighting are reduced and the environmental quality of PDL living is generally neglected.

Medical dispensaries and the rooms used by social workers, psychologists, teachers and advocates are often equipped with **air conditioning systems installed without due care being taken to ensure an adequate renewal of the air and without careful maintenance, turning them into a focal point for air contamination**.

It is therefore essential to conceive new models for simple and effective interventions, such as natural and mechanical ventilation systems, to be incorporated in an efficient way into the design and renovation of prison units, preventing the spread of respiratory infections. This initiative can bring numerous benefits, starting with the improvement in the life quality and health of inmates, as well as a reduction in disease treatment costs.

Attention should be paid to all the environments of the prison unit, which need to be conceived in a systematic form. Flows, long-stay locations and closed environments must be planned with special care to enable effective prevention of respiratory infections. Careful choice of the sites for building new penitentiary establishments, including factors such as the local vegetation, the wind regime and amount of sunlight, can also directly contribute to better health conditions in the prisons.

1. Current architectural guidelines

Brazil's **Law 7210/84 "Lei de Execução Penal"**,[19] better known as LEP, was instituted to define the conditions for executing custodial sentences. The law's text mentions at two different moments questions relating to prison architecture:

a) in Article 64, which assigns the National Council for Criminal and Penitentiary Policy (CNPCP) responsibility for establishing rules on the architectural design and construction of penal establishments and halfway houses.
b) in Article 88, *caput* and sole paragraph, which explains that the individual cell must be equipped with a sleeping area, washing facilities and lavatory, and the basic factors needed for a healthy environment, including ventilation, sunlight and temperature conditions adequate for human existence, with a minimum area of 6m^2.

In fulfilment of its responsibilities relating to the publication of rules for the architectural design and construction of penal establishments, the **CNPCP** published **Resolution 09/11**[5] on the **Basic Guidelines for Penal Architecture**, which replaced Resolution 03, issued in September 2005. Resolution 9/11 "introduced new concepts such as accessibility, soil permeability, bioclimatic comfort and environmental impact."Annex IV of this Resolution states: "It is essential to favour installations with a minimal level of comfort, looking for viable solutions that allow the required level of security."

In addition to these regulatory guidelines, there are various supplementary regulatory provisions, such as **Resolution 06/06**, also issued by the CNPCP, which standardizes the physical structure of the healthcare unit in prisons to provide services for up to 500 convicts.

Though less specific, the regulations, including RDC 50/02,[20] published by the National Health Surveillance Agency (ANVISA) sets out the technical norms for planning, programming, elaborating and evaluating the physical design of healthcare establishments.

European penitentiary rules for the treatment of prisoners, published in Recommendation 2005 and approved on January 11th 2006 by the Committee of Ministers of the Council of Europe,[6] states, in Part II of the text, "Conditions of imprisonment", that prison spaces must obey the minimum accommodation requirements. Item 18.1 stipulates that: "The accommodation provided for prisoners […] shall respect human dignity and, as far as possible, privacy, and meet the requirements of health and hygiene, due regard being paid to climatic conditions and especially to floor space, cubic content of air, lighting, heating and ventilation."In addition, Item 18.2 requires that: "In all buildings where prisoners are required to live, work or congregate, the windows shall be large enough to enable the prisoners to read or work by natural light in normal conditions and shall allow the entrance of fresh air."

LOCATION OF THE PRISON UNIT

Among the parameters to be considered when choosing the land for installing a prison unit, according to the guidelines contained in **Resolution 09/11 of the CNPCP**,[5] are: "ease of access, speed of communications and socioeconomic convenience, that is, the use of basic services and existing communications (means of transport, water and energy supply, sewage network, etc.) and available

reserves (water, vegetation, mineral deposits, etc.), as well as the particularities of the surrounding area."

According to Annex IV of Resolution 09/11 of the CNPCP: "It is important to observe the topography and orientation of the proposed site for the implementation of the building, which will have a direct impact on the sunlight and natural ventilation, taking into account the regional climatic conditions and respecting the local area's particularities in terms of natural air circulation, ventilation and lighting." "In principle, all solutions are acceptable, but measures will have to prove capable of providing functionality, security, comfort and environmental impacts," which include natural ventilation and lighting conditions. Still according to the same Resolution: "The origin of the prison population is one of the basic indicators for localization, so as not to prevent or hinder prison visits or the preservation of the social connections necessary for the harmonious reintegration of prisoners on their release."

International guidelines also recommend that prisoners are incarcerated in locations close to their families as a way of ensuring social and physical support, which means distributing the prison units across the Brazilian states and avoiding the use of large complexes in the metropolitan regions.

CAPACITY OF THE PRISON UNIT

Resolution 09/11 of the CNPCP[5] estimates various allocation patterns for prison units. Table 1 indicates maximum capacities according to the type of penal establishments.

"The Prison Complex has an unlimited capacity, as long as the various establishments making up the complex respect the capacities fixed for it previously and are independent from each other. Under no circumstances can a cell module exceed the capacity of 200 prisoners."

Annex V of the same resolution sets out the requirements for each type of prison establishment and defines the minimum areas for each of the components of the diverse modules (prison officers, screening/inclusion, healthcare, prison treatment, multi-use unit, school/education, workshops, intimate visits, collective living spaces, individual living spaces, nursery and crèche, and

Table 1. Overall capacity of penal establishments[10]

Penal establishment	Maximum Capacity
Maximum security penitentiary	300
Medium security penitentiary	800
Agricultural colony, industrial colony or similar	1.000
Halfway house or similar	120
Criminological Observation Centre	300
Public Jail	800

so on). Annex IV stipulates the minimum dimensions for the cells, specifying area, diameter and volume according to the number of occupants (Table 2).

QUESTIONS REGARDING NATURAL VENTILATION AND LIGHTING

The following recommendations are included in annex IV, Chapter 3.1, of Resolution 09/11 which covers "Environmental comfort (natural ventilation and lighting)":

- "The total area of openings of the compartments should be a minimum of 1/8 to 1/6 of their floor area, depending on the bioclimatic zone in which the penitentiary establishment is located, in order to ensure adequate air circulation in the environments, also meeting the regulations set out in NBR 15220/2003 for natural ventilation conditions by bioclimatic region."
- "The environments should allow cross ventilation. For this, the ratio between inlet and outlet openings must be at least 0.5 for the air to circulate."
- "In addition, the air inlets should be located with the aim of producing a current of air at the height of the users of the various environments, in order to ensure physiological cooling, as well as renewal of the air."
- "In areas subject to low temperatures during winter, the openings should be able to be closed, allowing control of the ventilation in these environments."
- "In regions where lulls are frequent, mechanical ventilation systems must be installed. These systems must be able to function as exhaust fans."
- "An adequate balance should be sought between the benefits to the health of the environment produced by sunlight and the discomfort caused by overheating of internal spaces."

Table 2. Minimum dimensions for cells

Type	Capacity (places)	Minimum Area (m^2)	Minimum Diameter (m)	Minimum Volume (m^3)
Individual cell	1	6.00	2.00	15.00
Collective cell	2	7.00	2.00	15.00
	3	7.70	2.60	19.25
	4	8.40	2.60	21.00
	5	12.75	2.60	31.88
	6	13.85	2.85	34.60
	7	13.85	2.85	34.60
	8	13.85	2.85	34.60

2. Technical recommendations for environmental interventions

Architectural interventions intended to improve the environmental conditions in prisons should take into account the frequency and intensity of winds at each site. Even in the same region, environmental conditions have local particularities, which must be taken into account in the design of the projects and interventions, including interferences due to the wind regime caused by the site's topographic and urban surroundings.

NATURAL VENTILATION AND LIGHTING

Since overcrowding combined with the confinement of people in poorly ventilated spaces with little natural light is an important determining factor in the high incidence of tuberculosis and other respiratory diseases in prisons, careful use of lighting and ventilation can contribute substantially diminish the transmission of these illnesses by ensuring the dilution and depletion of contaminants, or the destruction of TB bacilli, which have little resistance to sunlight.

As well as health-related benefits, the optimized use of natural light and ventilation in buildings can contribute significantly to the reduction in energy consumption and also promote an improvement in the environment by providing thermal and visual comfort for their occupants.

As a first step, the ventilation of the environments must be rigorously observed, with analyses of wind patterns in the

Whenever possible, priority should be given to the use of natural lighting and ventilation resources rather than artificial sources which add costs, consume electricity and require maintenance.

local area and its prevailing directions. The layout of the different buildings making up the prison complex must be planned to favour air circulation between the structures and to prevent them blocking sunlight to other buildings. The minimum distances between buildings required for placing windows must be determined using as reference the construction guidelines for each location.

As parameters for ventilation and lighting, we recommend using openings equivalent to 1/6 of the floor area[21] (Figure 1), taking care not to include opening areas between closed and internal environments.

An adequately sized opening, however, does not by itself guarantee good air circulation (Figure 2). This requires a flow of air with inlet and outlet points. This flow can be provided through the principle of pressure difference, or through the adoption of devices to direct the prevailing winds identified in the local area.

For **cross ventilation**, openings can be placed on opposite walls (Figure 3), at two levels on the same wall (Figure 4) or on wall and roofing, with skylights* (Figure 5), which function through pressure differences, causing a stack effect * when there is sufficient distance between the floor and roofing (at least two floors), or sheds* angled to channel the prevailing winds (Figure 6).

Attention should also be paid to the positioning of the openings so that the air circulates throughout the entire environment, especially in those areas where people stay for longer periods. The current of air should not pass directly on one side only, or above, nor should it be blocked by partitions or furniture, as occurs when bunk beds* are constructed as niches.*

The lower beds of bunk beds, especially when ventilation is only adopted in the upper part of the cell, are critical locations in terms of air renewal. Whenever possible, windows placed at two levels should be used, or small perforations in the walls, in order to ensure a more uniform circulation of air throughout the room, especially in the bed area, the place where the inmates stay most and consequently the most likely to contain high concentrations of bacteria.

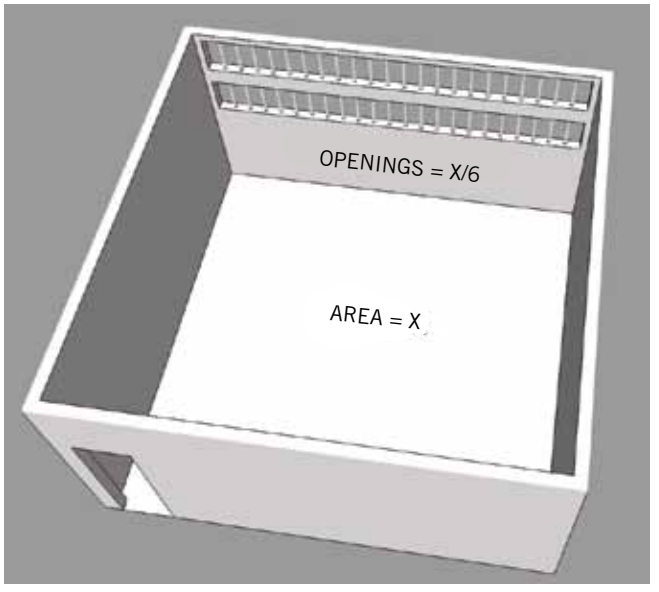


Figure 1. Size of openings

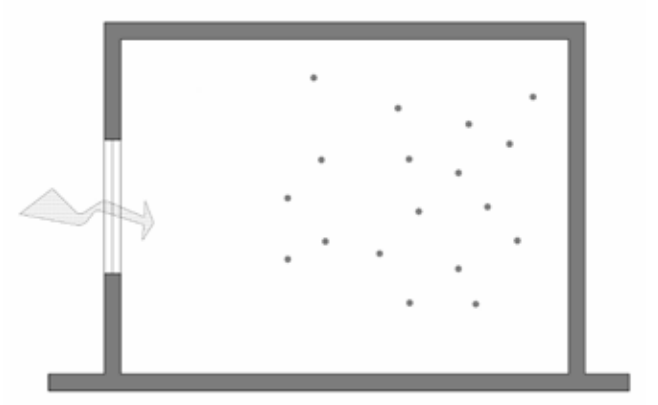


Figure 2. Environment with poor air circulation

* Terms marked with an asterisk are defined in the glossary.

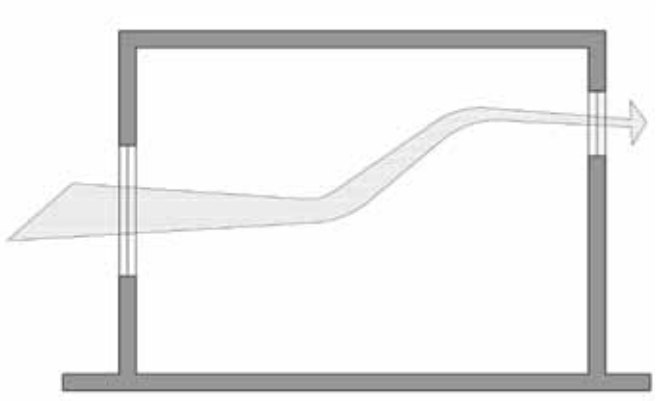


Figure 3. Cross ventilation

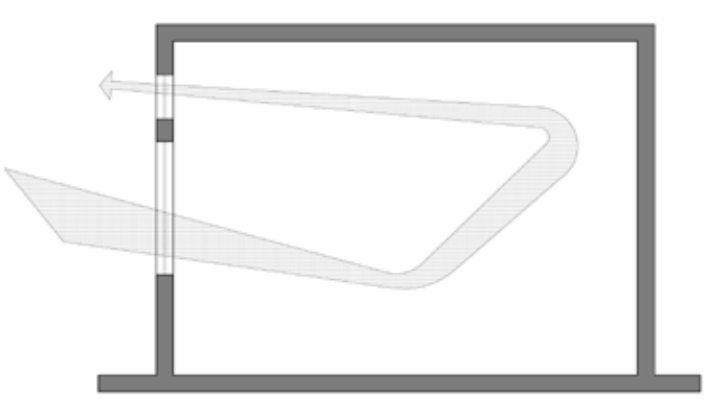


Figure 4. Split-level ventilation

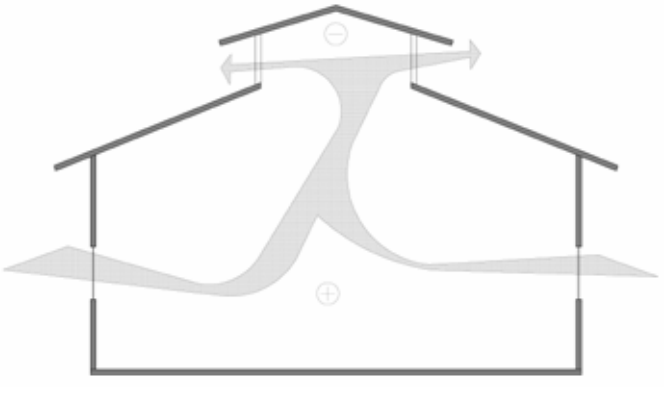


Figure 5. Roof lantern*: stack effect*

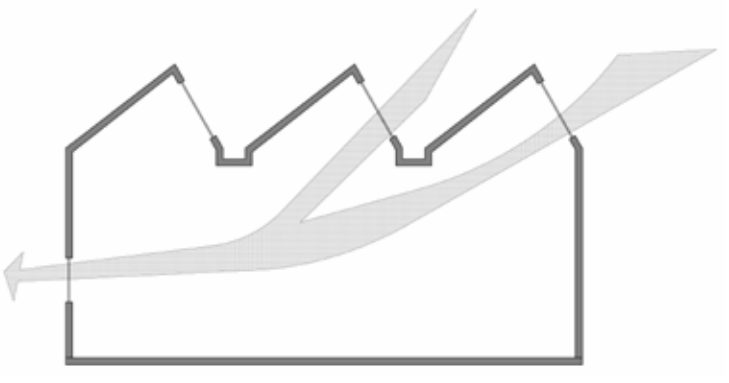


Figure 6. Shed*: channelled wind

From the security point of view:

- Small wall openings should be used between the bunk beds* (30cm above the level of the mattress) and above the cell door at an angle of ±45°.
- Small perforations must maintain the structure intact, and special care must be taken when introducing these alterations in pre-existing buildings to ensure that the unit's security is not compromised.
- Where the possibility of inmates monitoring actions and procedures undertaken in the corridor may compromise security procedures, these small perforations should not be used on the wall dividing the cell from the circulation in the prison-wings. Such problems do not exist when the cell doors are barred.
- These perforations should also not be used on walls dividing cells from the external area of prison wings where there is a possibility of the inmate monitoring security procedures or communicating with these external areas (recreational area, patio or other environments) whose use is shared with other inmates. However, perforations can be used, associated with screens* to block the view, where the environment next to the cell is an area forbidden to the prisoners.

Today, there is a tendency to build cell with niche-type beds, that is, enclosed parallel to the walls with solid partitions separating the beds (Figure 7). However, this type of layout hinders the circulation of air in the bed area, the location where prisoners remain for many hours. This configuration is worsened when triple bunk beds* are used, especially when the distance between the beds is very small. In the case of triple bunk beds, the ceiling height of the cell must be at least 3.5m.[5]

Positioning the beds perpendicularly to the wall allows a better circulation of air between the beds and creates a more suitable and healthier space (Figure 8). Where the cell lacks the space to position the beds perpendicularly to the walls, it is important to avoid blocking air circulation with walls between the beds. Walls with perforations or just columns between the beds (Figure 9) should be used. The distance between the beds should also allow individuals to sit up without banging their head on the bed or ceiling above. Triple bunk beds should be avoided wherever possible

The need for natural ventilation and lighting of cells and other environments used collectively by inmates must be reconciled with security issues.

Figure 7. Niche-type bed

Figure 8. Beds parallel to the wall without blocking air circulation

Figure 9. Beds parallel to the wall without blocking air circulation

since they are more likely to lead to accidents, make inspection more difficult and hinder air circulation within the bed area.

Another important factor for architectural projects in prisons is **ensuring the entry of direct natural light**, since, as mentioned earlier, the tuberculosis bacillus is highly susceptible to the action of the ultraviolet rays present in sunlight. Consequently, **pergolas,*roof lanterns*, skylights*, sheds*, windows and cobogos***should be designed to maximise the use of natural light.

It is important to note that when very intense sunlight enters through windows in regions with hot climates, PDLs tend to intervene by placing screens which limit ventilation and lighting, looking to reduce the discomfort caused by excess luminosity, especially close to the beds. The openings should be positioned, therefore, to ensure good illumination without generating the 'need for intervention' by the user, which ends up compromising the projected system. Likewise, in regions with cooler climates, windows and openings should be fitted with devices that allow them to be closed when necessary.

Solid screens used to block the view of external areas from the cells or communal areas used by the prisoners should be placed at least 1.5m from the windows so as to avoid impeding the circulation of air and entry of natural sunlight.

For security reasons, it is recommended that skylights* are not used in cells since they undermine the security of the prison unit. When employed in areas used communally by PDLs, they should be fitted with bars.

In some circumstances, natural ventilation is not sufficient to ensure the exchange of air necessary to insure the salubrity of the environment, as in locations where large concentrations of people live and/or where windows are located in positions unfavourable for capturing wind.

Hence, in prison environments, with a large number of spaces, difficulties in ensuring natural ventilation and a high likelihood of air contamination, mechanical air extraction systems with low maintenance requirements become a suitable option.

In these circumstances, to ensure an adequate exchange of air, forced circulation should be adopted in order to generate negative pressure within the environment by removing air. Whenever the volume of air removed from a closed system is larger than the volume inserted, the system is said to be under negative pressure. Negative pressure can be obtained by using **extractor fans, which should produce between 6 and 12 exchanges per hour.**[22]

Naturally, air moves from higher pressure to lower pressure areas. Hence, when the air pressure within the ambient becomes lower than in adjacent areas, the air tends to enter through the small openings, thus avoiding the return of contaminated air to the corridors or neighbouring areas.

Figure 10. Industrial fan and wind-powered extractor*

MECHANICAL VENTILATION SYSTEMS

The choice of mechanical ventilation system to be used to increase the exchange of air will vary according to the specificities of each building, the local environmental conditions, wind patterns and the necessary maintenance procedures. Mechanical equipments (fans) are used to increase ventilation rate of the facility, which can be achieved through blowing or extracting air or a combination of both (mixed system).

These systems can be composed by individual items of equipment, placed in each space, according to the flow capacity (Figure 10), or assembled in centralized networks linked via ducts (Figure 11).

Individual items of equipment (figure 10) can be rotated by the wind **(wind-powered extractor*)** or powered by electricity **(in-**

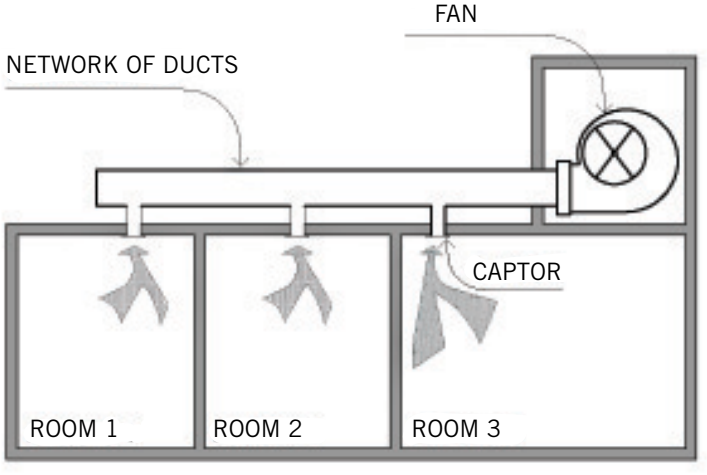


Figure 11. Diagram of networked mechanical air extraction system

dustrial fan). Individual electrical equipments are recommended for localized installations in one or other room of the prison unit. Wind-powered extractor fans can be installed in locations with a high incidence of winds or environments whose physical characteristics enable air movement via pressure difference, and represent an economic solution with easy maintenance.

Networked mechanical air extraction systems are basically composed of a centrifugal fan linked to main ducts that branch out and connect to the compartments via extraction outlet in the ceiling of the building (figure 11). A local installation of a networked mechanical air extraction system essentially consists of the following parts:

Captor – device for capturing air containing contaminants, placed in the location where these originate;

Fan – equipment capable of producing air thinning or depression, which displaces the contaminated air to the fan's inlet, while positive pressure ensures that this air leaves the fan and disperses into the outside atmosphere or to air treatment equipment;

Network of ducts* – system that conducts the contaminated air from the captor to the fan, and from the later to the exterior or to treatment equipments.

The project design for an extraction system begins with the choice of captor. Through the difference in pressure between the ambient air and the air inside the captor, the device generates an air current inside the latter. The air current then travels through the ducts to the extractor fan. To ensure a quick flow, a partial vacuum or depression within the captor is needed. Two speeds need to be taken into consideration: the speed of the flow along the ducts, and the speed at which the air moves from the location where the contaminants are produced to the inlet of the captor.

The mechanical air extraction systems must be designed to meet the standards of the Brazilian Association of Technical Stan-

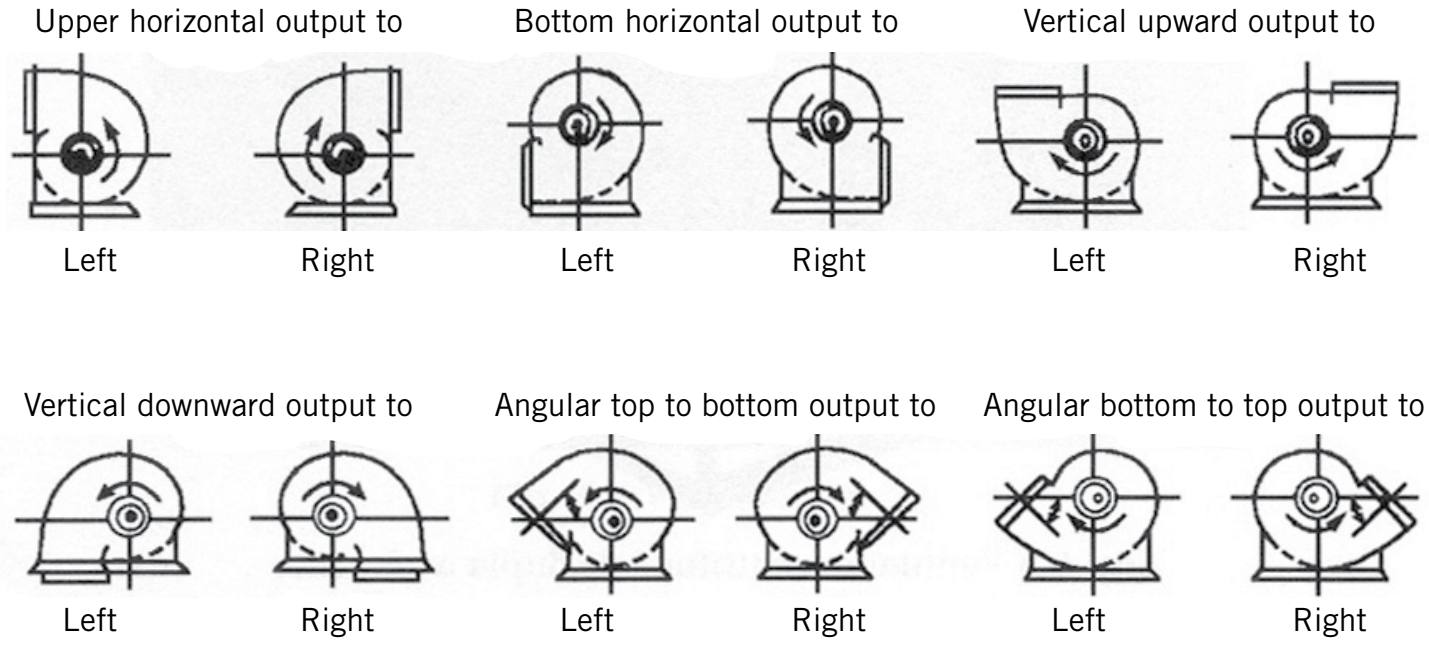


Figure 12. Model of centrifugal fans with various installations according to the air outlet

dards (ABNT).[23] The architectural characteristics of the building are determining factors in defining the route taken by the ducts. Some recommendations for an adequate design of this type of system are detailed below:

Fans

The fans used should be centrifugal with backward curved rotor blades, since these produce less noise and have a lower risk of overloading the motor, but they require more rotation (figure 12). The inlet and outlet for the extracted air depend on their positioning within the air extraction system in question. The extracted flows of air should correspond to around 5% of the project values stipulated by the regulatory standards. The electromechanical potency of the fan-motor assembly will be determined by the capacity for air renewal (extraction) within the environment under consideration, the length of the duct network and the external outlet point.

Ducts and captors for extracting air from environments

- Interconnections with the main duct should be made using elements from the same section of opening as the captors, with the size of each main duct calculated according to the project in question;
- The ducts of the main network should be fitted with devices that prevent the internal propagation of smoke caused by fires;
- The main extraction network should be positioned above the ceiling/roof lining, with its size designed to meet regulatory standards in relation to the maximum internal velocity of the duct (capture speed); it must also obey the maximum permitted noise level and be fitted with devices that prevent any kind of physical communication between one area and another;
- Automatic back-pressure valves should be installed to prevent return flows of air in the duct when the extractor fan stops functioning;
- It is not advisable to use rectangular tubes for extraction systems since the sharp corners facilitate the accumulation of dust, therefore requiring a more powerful motor to keep the tubing clear and maintain the necessary level of efficiency;
- Ducts should not exceed a maximum length of 20m. Where this is necessary, the best solution is to construct a new main

Security recommendations: grills should not be used on the inlets (air captor). The design should be based on figures 13 and 14. The diameter of tubes should be adapted to prevent access by hands and arms.

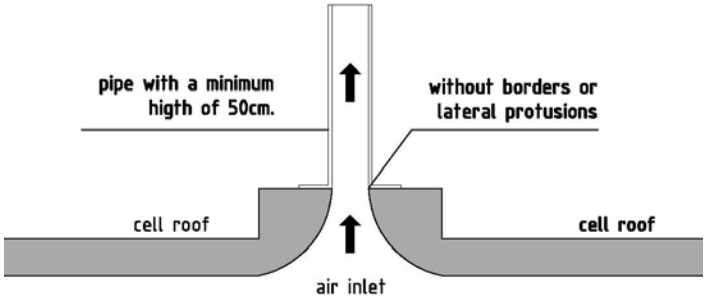


Figure 13. Air captor design

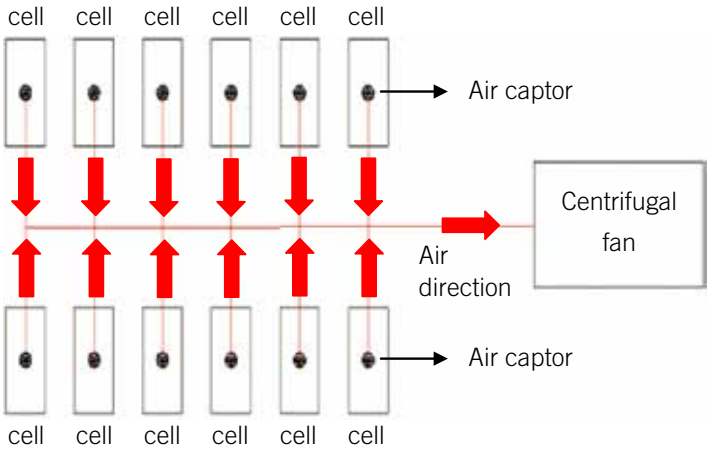


Figure 14. Duct network* design

duct line. Each main duct line, limited to 20m, should be installed with a centrifugal fan in its corresponding machine room. The centrifugal fans may be located in a single machine room. This layout will depend on sufficient architectural space being available in the roof, above the ceiling. The flow needed for renewal (extraction) of the air in the environments will be determined through the parameters set by the ABNT for this type of system, measured in m^3/h.

System design principles

The direction of the air movement should be observed in order to prevent the current coming from the cells i.e. the place where infected prisoners stay longest, from entering circulation and reaching the recreational area where other individuals will be exposed to contaminated air. The mechanical air extraction systems should be placed in the environment according to set procedures, in order to maximize and homogenize the circulation of air. With this aim in mind, the captor should be positioned on the opposite side to the new air inlet, ensuring that the air does not leave before mixing with the internal air (Figures 15, 16), while the air outlet from the extraction system (fan) should never be placed close to a building air inlet (Figure 17).

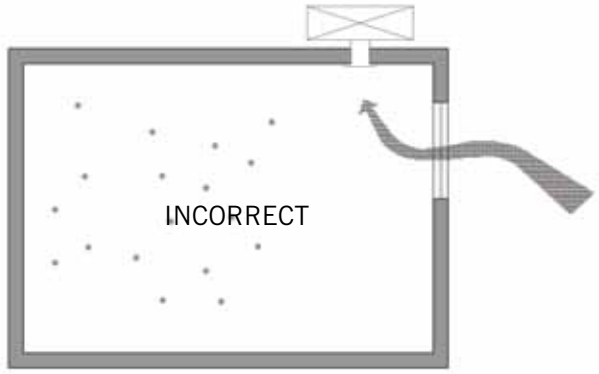


Figure 15. Incorrect positioning of mechanical air extraction system

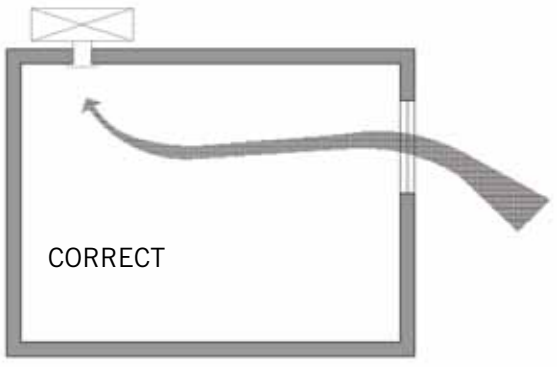


Figure 16. Correct positioning of mechanical air extraction system

AIR CONDITIONING SYSTEMS

The high temperatures typical of much of Brazil's territory and the low temperatures in the south of the country very often lead to the use of air conditioning systems.

Their use is not recommended in environments with a high risk of air contamination and in locations with a risk of failures in the equipment and infrastructure maintenance systems, which applies to the majority of Brazil's prison units.

In specific situations where air conditioning is unavoidable, the following **recommendations should be rigorously adhered**:

- Thesystem specified and installed should ensure that the blown air is extracted outside the environment using devices adequate to this function. **Air renewal (exchange) is an overriding priority.**

Although they provide increased thermal comfort, air conditioning systems can jeopardize the quality of the environment when they fail to ensure an adequate renewal of air or are not regularly maintained to ensure the quality of air blown into the space.

- **Maintenance of the air conditioning system** must always meet the minimum levels stipulated by the regulatory standards, avoiding, for example, condensation inside the blow duct and/or outlet during the system's on-off cycles.

ULTRAVIOLET GERMICIDAL LAMP

In specific situations with a high risk of contamination in which it is impossible to ensure adequate ventilation and sunlight, **ultraviolet germicidal lamps** can be used to provide continuous irradiation of the upper layer of air.[24] However, this technique is costly and demands a minimum level of air circulation and renewal within the environment, as well as considerable attention in terms of installation and maintenance of the system so as to avoid overexposure of individuals to the radiation.

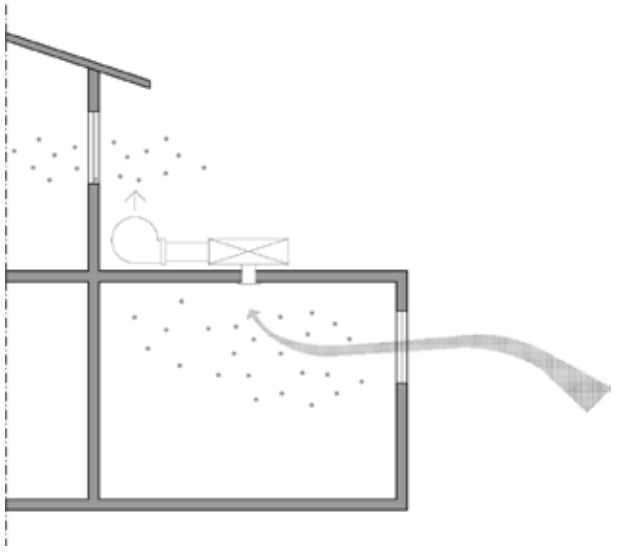


Figure 17. Example of recontamination of interior air

3. Projects and interventions

Presented below are a series of case studies with concrete examples from **incarceration areas** (cells and corridors) and **areas used collectively** by prisoners (visiting areas, classrooms and multi-use rooms). They analyse the main positive and negative characteristics in relation to temperature, lighting and ventilation, and propose interventions for solving the problems.

The adopted methodology also intend to encourage a critical as sessment of the architectural space by the various actors involved in the prison system, allowing them to perceive how small interventions, very often easy to execute at relatively little extra cost, can make a big difference to the environmental conditions.

This approach illustrates a procedure that should be applied systematically to all prison establishments, seeking to propose interventions that should be discussed with those responsible for security, taking into account the type of prison unit involved (closed, semi-open and open) and the level of security (maximum, medium) as well as the nature of each environment within the establishments.

Although these locations concentrate sick inmates (especially those infected by TB and HIV), in contact with each other and health workers, we have not presented examples from the prison health areas because they must meet the same biosafety criteria as outside health areas with a large flux of TB cases.[25-27]

These analyses are intended not only to propose interventions aimed at improving the health conditions of existing prisons, but also to offer guidelines for the construction of new prisons, thereby contributing to the prevention of transmission of tuberculosis in these environments.

In healthcare areas, particular attention must be given to the ventilation and lighting of waiting rooms, doctor's cabinet, sputum collection points and hospitalization areas (especially isolation structures for resistant cases of TB) and X-ray rooms.

CASE STUDY 1

CLIMATE: Equatorial –Northern Region

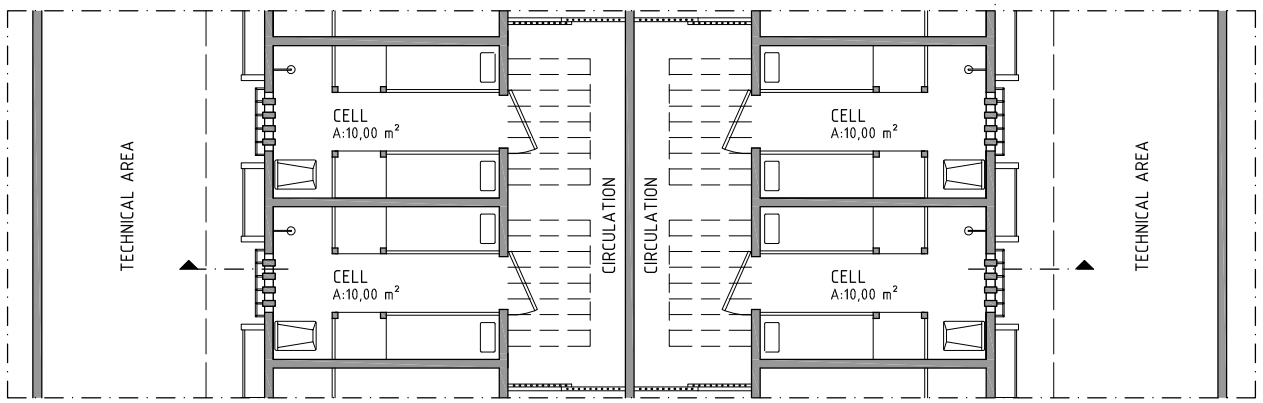
Small thermal variations* during the day, month and year. High relative air humidity*, reaching saturation levels. Intense rainfall and diffuse radiation*, low wind speeds with lull periods. Recommended: favour shade and circulation of wind.

POSITIVE CHARACTERISTICS:

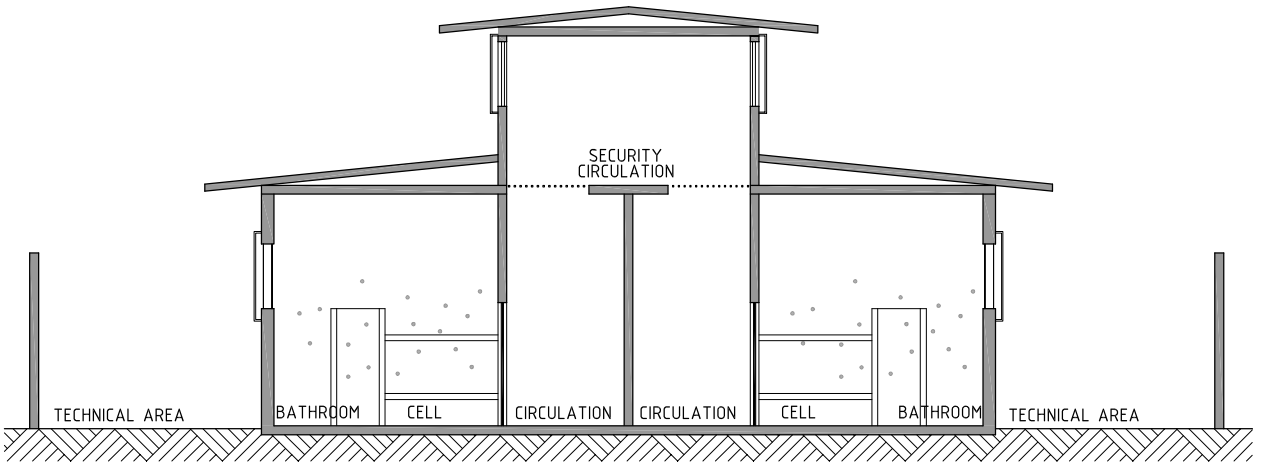
- Area of circulation for guards has openings to the cell corridors which allows air circulation through a stack effect*, a good resource especially in regions with low wind speeds.
- Cell windows are not blocked by the bathroom dividing wall.

NEGATIVE CHARACTERISTICS:

- Cell windows area is smaller than 1/6 of the floor area, the size recommended for ensuring adequate natural ventilation and lighting;
- Cells do not have cross ventilation;
- Absence of ventilation between the ceiling and the roof above the cells;
- Lower part of the cell is poorly ventilated.



GROUND FLOOR PLAN
SCALE: 1/125



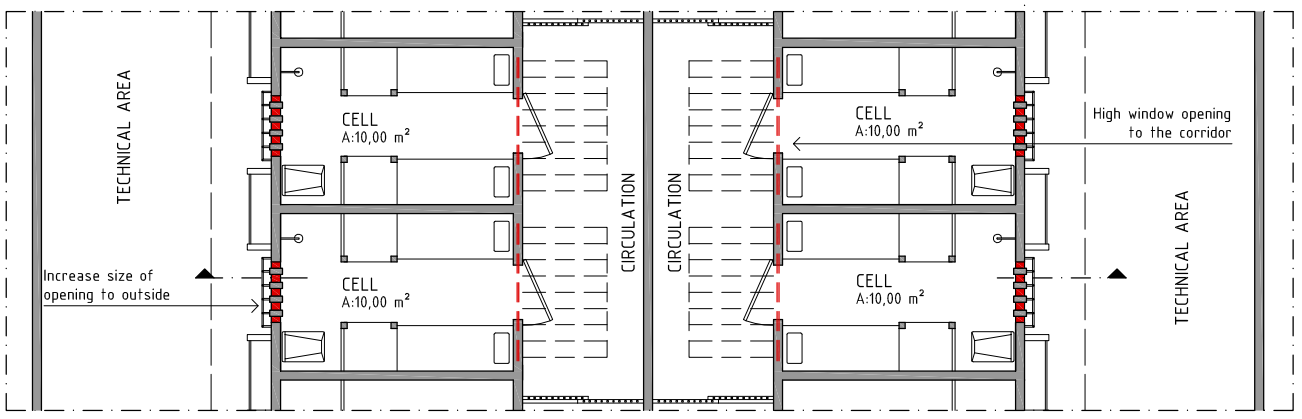
SECTION
SCALE: 1/125

INTERVENTIONS:

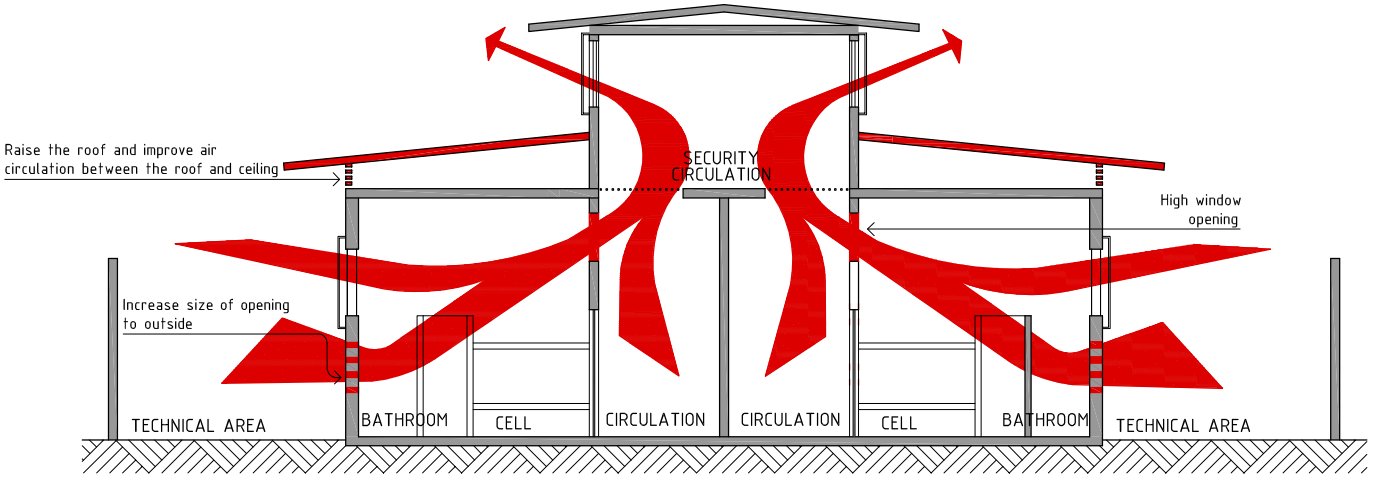
- Insert tall window between the cell and the circulation area to allow cross ventilation and natural lighting of the cells;
- Increase the opening to the exterior ensuring that it is equivalent to 1/6 of the cell floor with perforations in the lower part of the cell, allowing a more uniform circulation of air;
- Increase the roof height and allow air to circulate between the roof and ceiling.

SECURITY OBSERVATIONS:

- Opening small perforation to the exterior will not cause security problems since they will face the technical area where prisoners do not circulate and there already exists a screen* blocking the view.



GROUND FLOOR PLAN
SCALE: 1/125



SECTION
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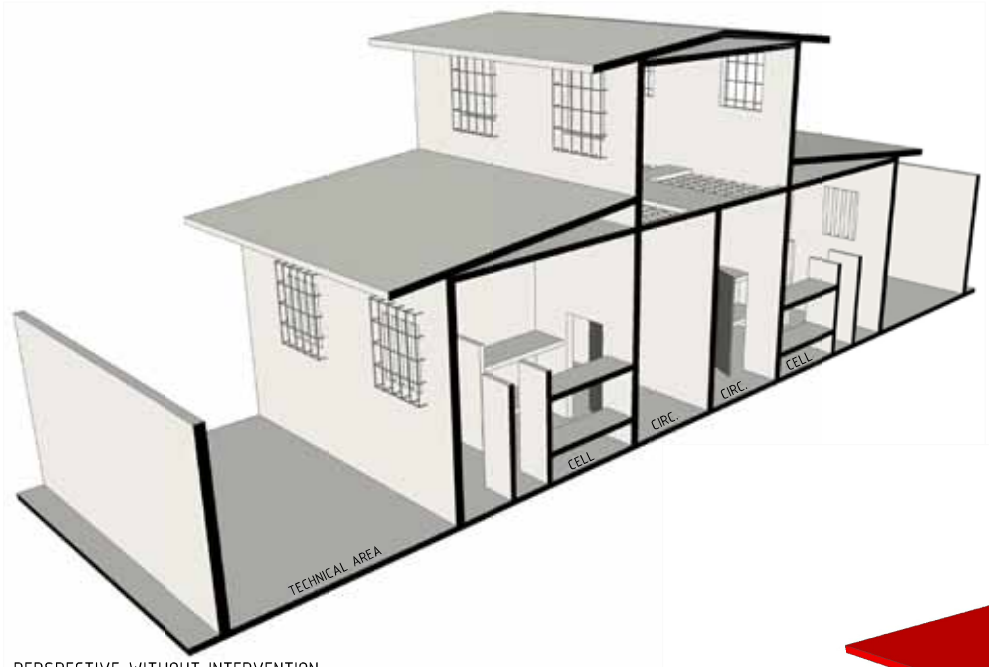
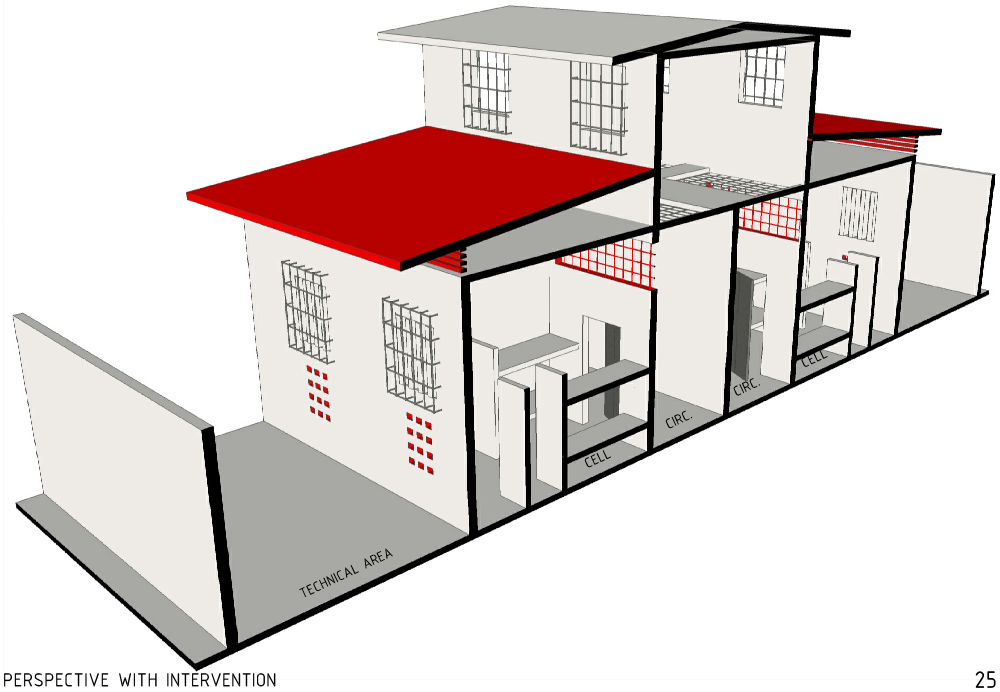


PERSPECTIVE WITHOUT INTERVENTION



PERSPECTIVE WITH INTERVENTION

25

CASE STUDY 2

CLIMATE: Equatorial –Northern Region

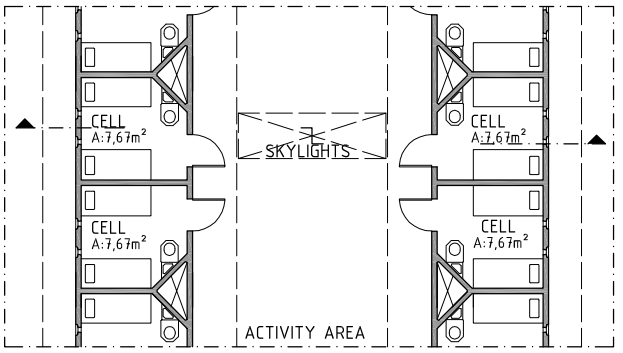
Small thermal variation* during the day, month and year. High relative air humidity*, reaching saturation levels. Intense rainfall and diffuse radiation*, low wind speeds with lull periods. Recommended: favour shade and circulation of wind.

POSITIVE CHARACTERISTICS:

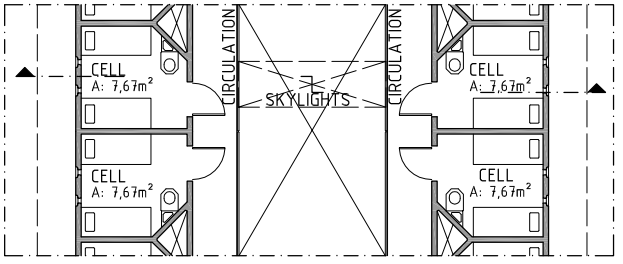
- Skylights* allow natural light to enter the corridors and activity area;
- The location of the technical floor above the cells avoids direct sunlight on the cell ceilings. This reduces the thermal load on the second floor.

NEGATIVE CHARACTERISTICS:

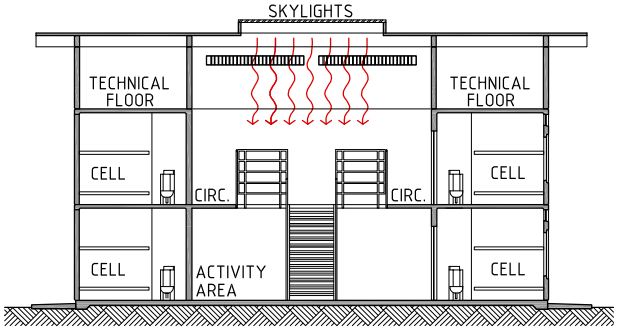
- Cells have only two small sealed window slits* for natural lighting and two tiny perforation for ventilation, corresponding to far less than 1/6 of the floor area, the size recommended for ensuring adequate natural ventilation and lighting;
- Skylights* without outlet vents produce a greenhouse effect and are inadequate for tropical and semi-tropical regions;
- The activity area and circulation area of the cells do not have the right size openings.



GROUND FLOOR PLAN
SCALE 1:200



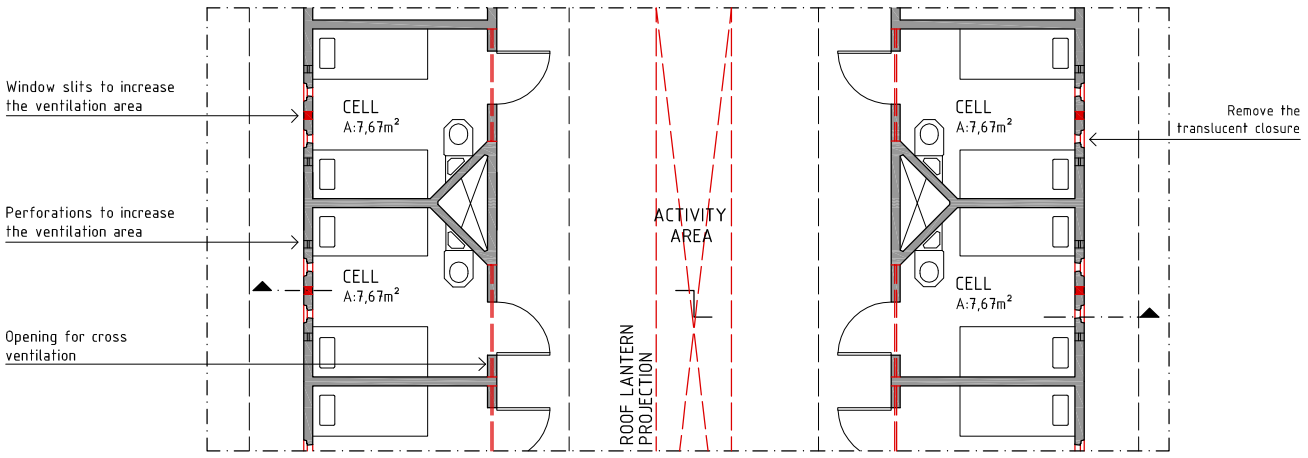
SECOND FLOOR PLAN
SCALE 1:200



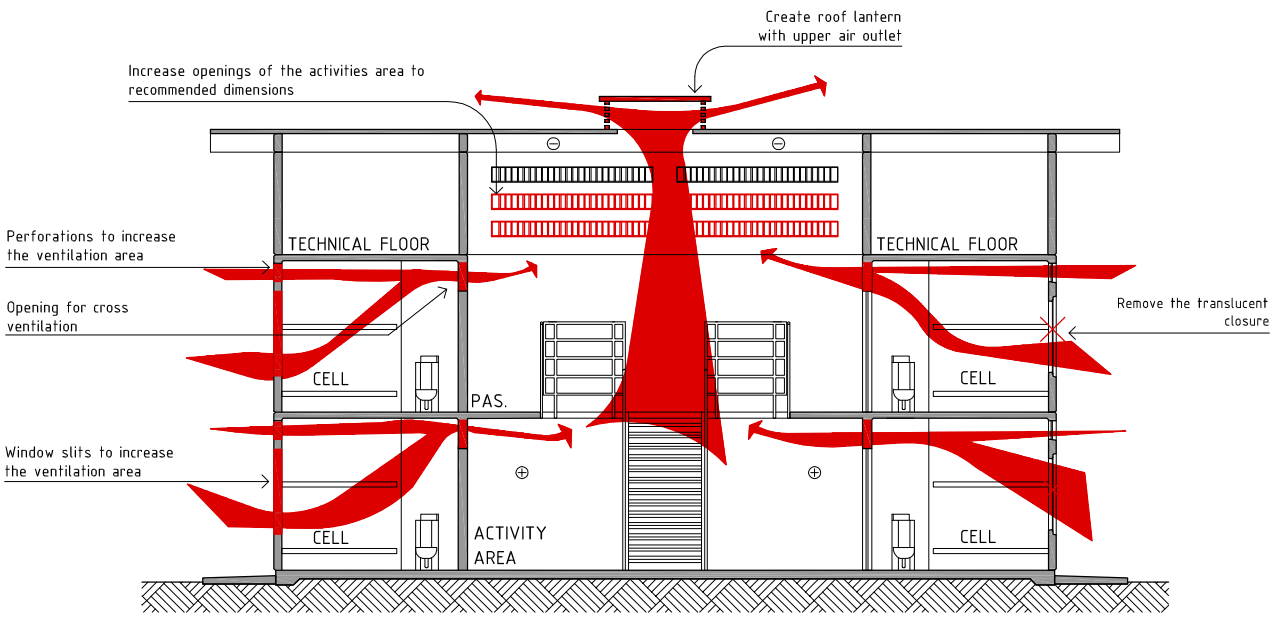
SECTION
SCALE 1:200

INTERVENTIONS:

- Introduction of new window slits* to ensure a ventilation area corresponding to 1/6 of the cell floor area;
- Opening of a high window in the wall between the cell and the corridor to allow cross ventilation;
- Change of skylight* to roof lantern* with an open area for ventilation, thus avoiding the incidence of direct sunlight;
- Increase the size of the opening in the back wall to meet the recommended size of ventilation opening for the corridor and activity areas;
- Remove the fixed translucent closure or swap for a mechanism that allows it to be opened and closed.



GROUND FLOOR PLAN
SCALE: 1/125



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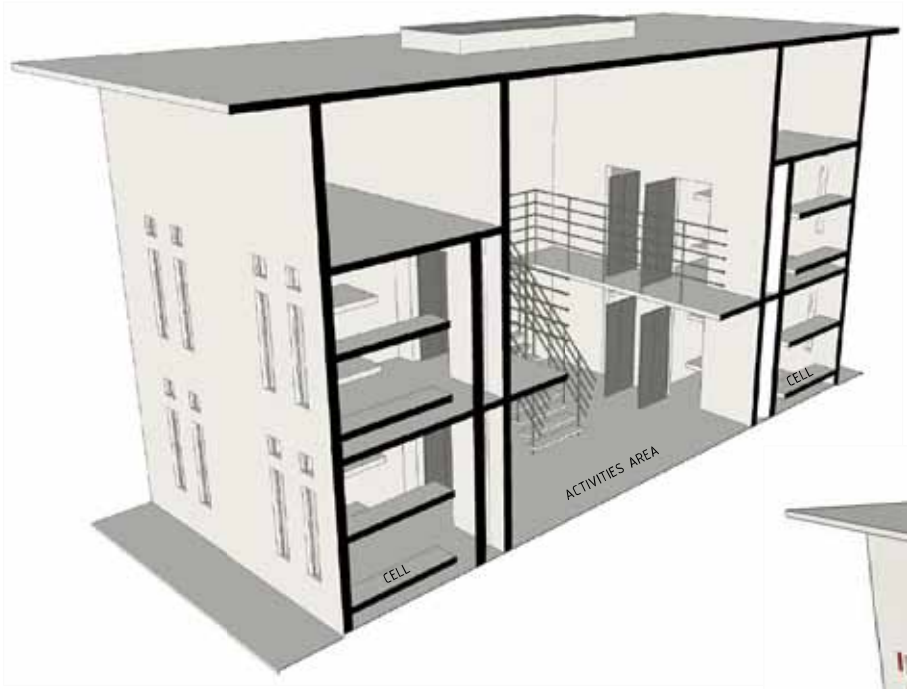


PERSPECTIVE WITHOUT INTERVENTION

PERSPECTIVE WITH INTERVENTION

CASE STUDY 3

CLIMATE: Tropical Atlantic or Maritime – Coastal region of the Northeast (NE) and Southeast (SE)

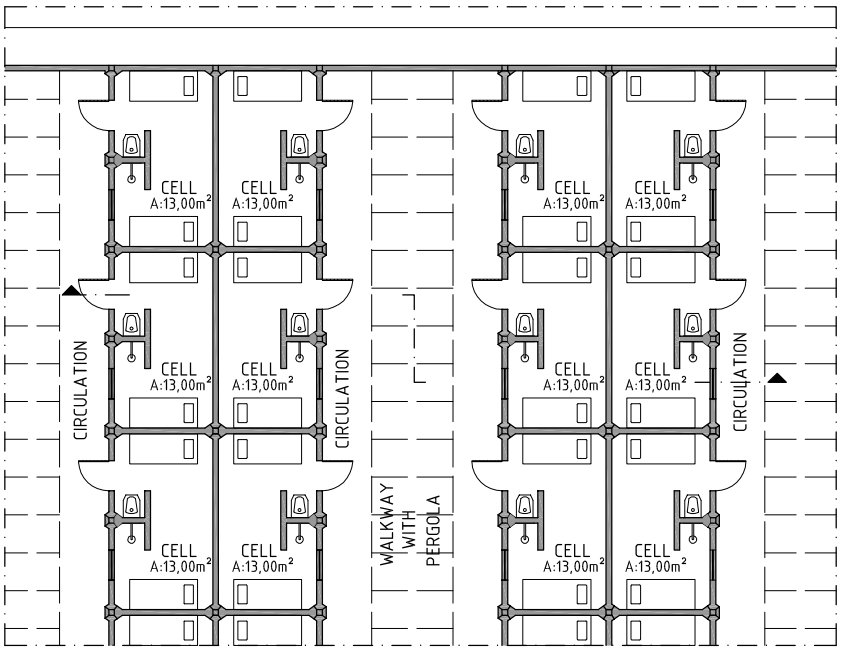
Seasonal cycle with little variation in the NE region. Higher temperature variations in the SE region during autumn and winter. Variable relative air humidity* with uncomfortable periods during the summer. Intense rainfall in the summer in the SE region and during autumn and winter in the NE region. In the SE region, attention should be paid to the period of lower temperatures.

POSITIVE CHARACTERISTICS:

- Leisure area with pergola* in front of the cells, limiting direct sunlight in the circulation area.

NEGATIVE CHARACTERISTICS:

- Design of cells backed onto each other does not allow cross ventilation;
- The ventilation from the ground floor to the roof does not function according to the principle of pressure difference, since a greater height difference is required for this air movement to occur;
- The ventilation openings in the cells are very unevenly distributed;
- The width of the patio covered by the pergola* is insufficient to allow wind to enter, which leads to the air passing directly over the buildings;
- The openings area in the cells is less than 1/6 of the floor area;
- The covering of the cells with a sloping ceiling without insulation has a bad thermal result for an environment located in a hot climate;
- The design compromises the entry of natural sunlight into the cells since the only openings are facing a covered area of circulation.



GROUND FLOOR PLAN
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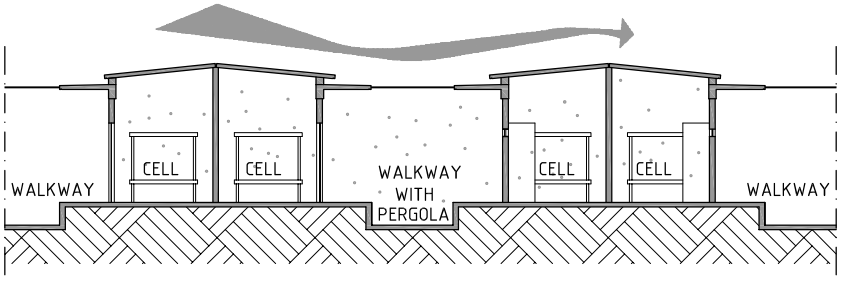
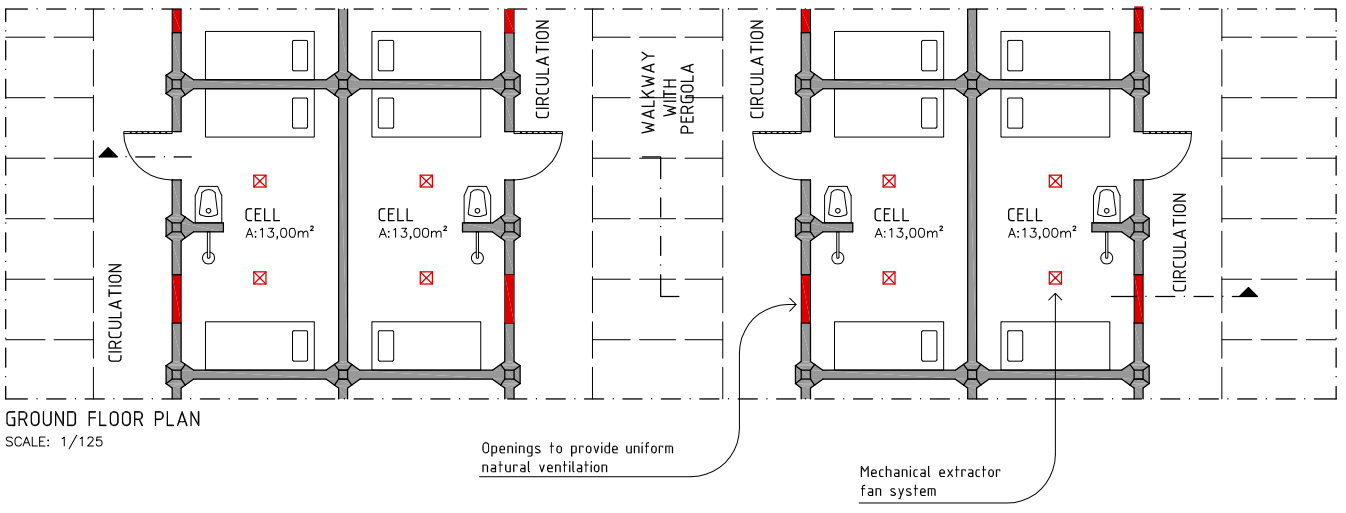


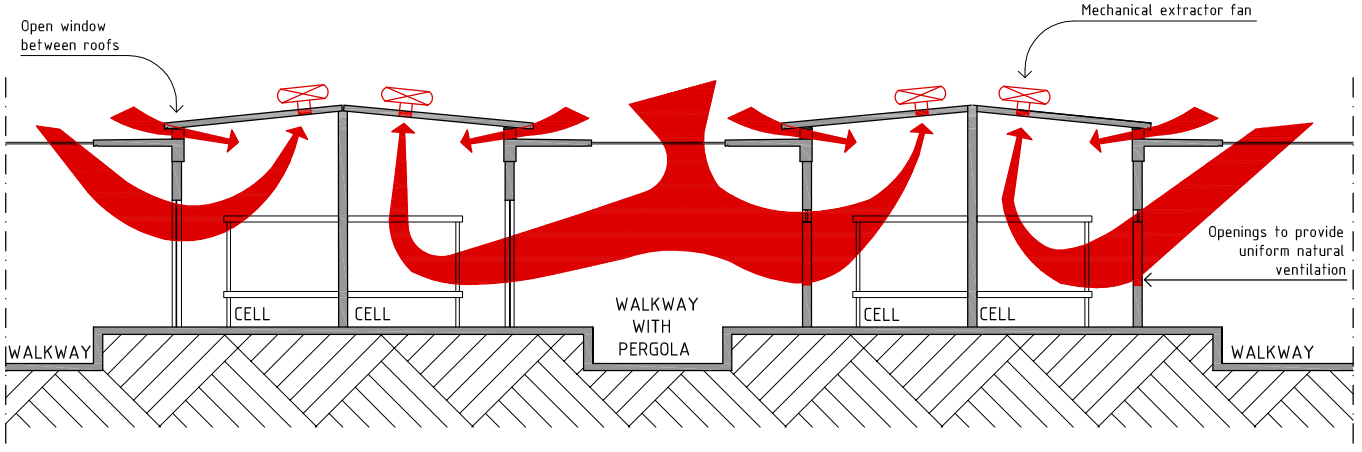
SECTION
SCALE: 1/200

INTERVENTIONS:

- Installation of mechanical air extraction system in each cell to induce air movement;
- Introduce a window between the cell ceilings and the circulation area;
- Increase the size of the windows to homogenize air circulation.



GROUND FLOOR PLAN
SCALE: 1/125



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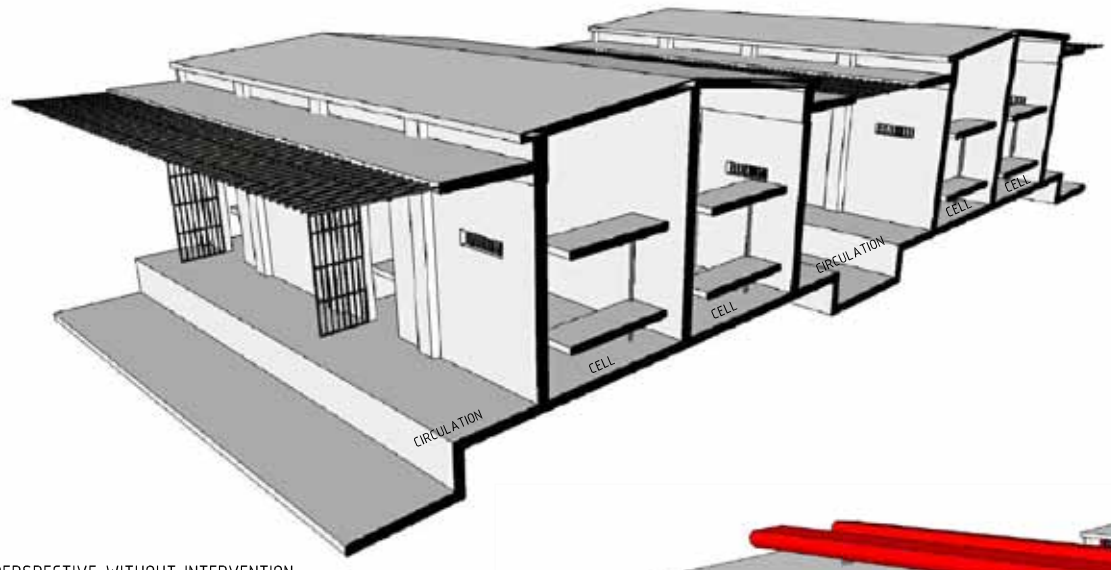


PERSPECTIVE WITHOUT INTERVENTION

PERSPECTIVE WITH INTERVENTION

CASE STUDY 4

CLIMATE: Tropical Atlantic or Maritime – Coastal region of the Northeast and Southeast

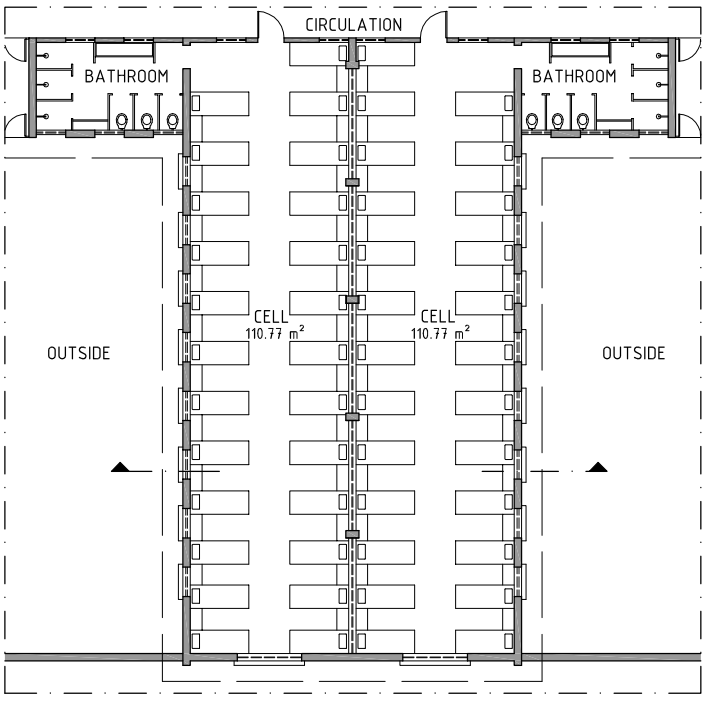
Seasonal cycle with little variation in the NE region. Higher temperature variations in the SE region during autumn and winter. Variable relative air humidity* with uncomfortable periods during the summer. Intense rainfall in the summer in the SE region and during autumn and winter in the NE region. In the SE region, attention should be paid to the period of lower temperatures.

POSITIVE CHARACTERISTICS:

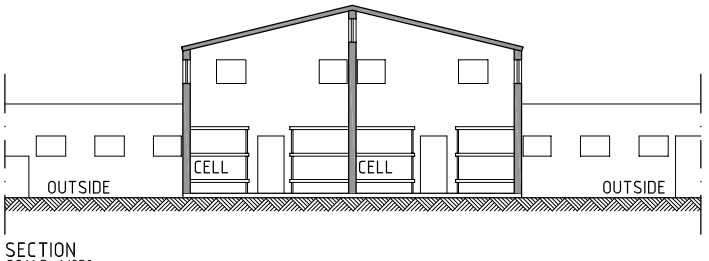
- The design allows cross ventilation;
- Windows to the outside on two different sides of the space;
- The size of the openings facing exterior is equivalent to 1/6 of the floor area of the space.

NEGATIVE CHARACTERISTICS:

- The openings between the cells allow contaminated air to circulate between the two environments;
- Air circulation is not uniform within the cell since all the openings are located in the upper part;
- The large number of prisoners housed in the cells requires mechanisms that ensure air renewal and prevent contaminated air from circulating in the environment.



GROUND FLOOR PLAN
SCALE: 1/250



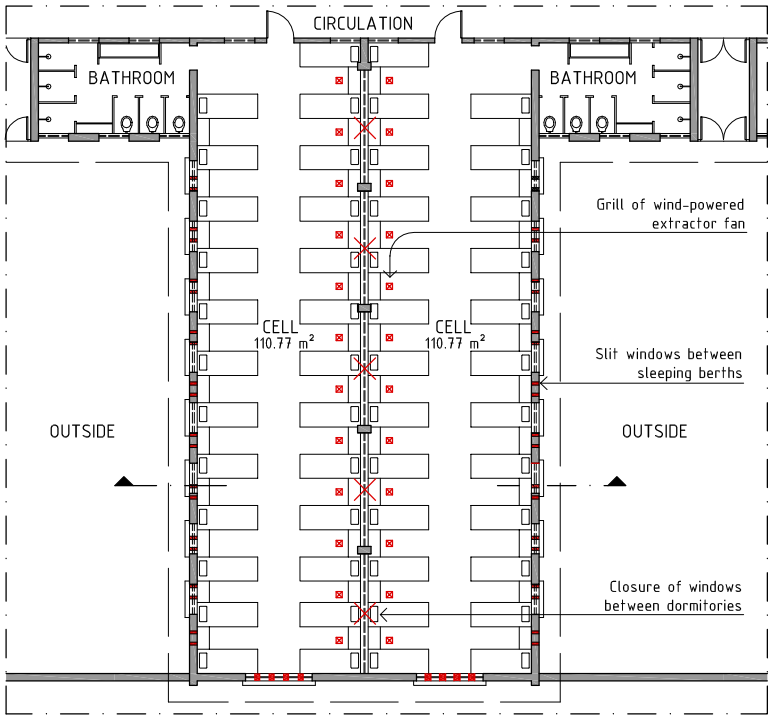
SECTION
SCALE: 1/250

INTERVENTIONS:

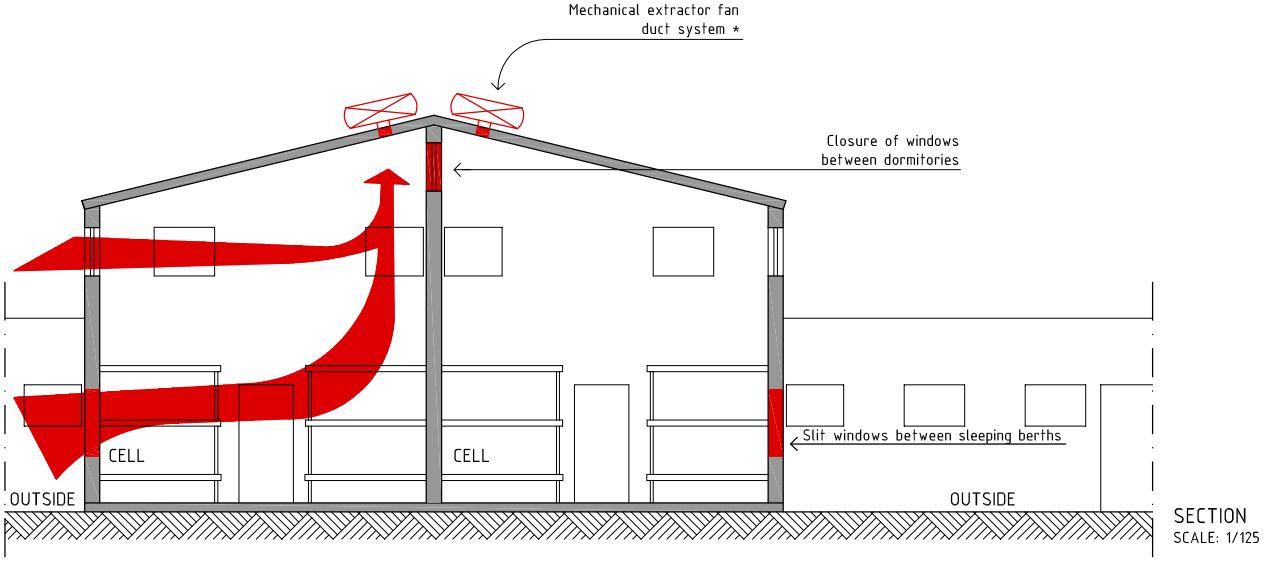
- Close the windows between the two adjacent dormitories;
- Insert extraction grills between each line of bunk beds,* parallel to the corridor, so as to eliminate contaminated air.
- Introduce perforations, window slits* or a window in the lower part of the cells in order to homogenize air circulation and ensure the ventilation opening is equivalent to 1/6 of the dormitory's floor area.

SECURITY OBSERVATIONS:

For security reasons, the proposed solution with perforations, window slits* or windows in the outside wall of the cells is only possible if the area exposed is not used by prisoners. Screens* may be needed to block the view if the opening allows communication and surveillance of the outside area by prisoners.



GROUND FLOOR PLAN
SCALE: 1/250



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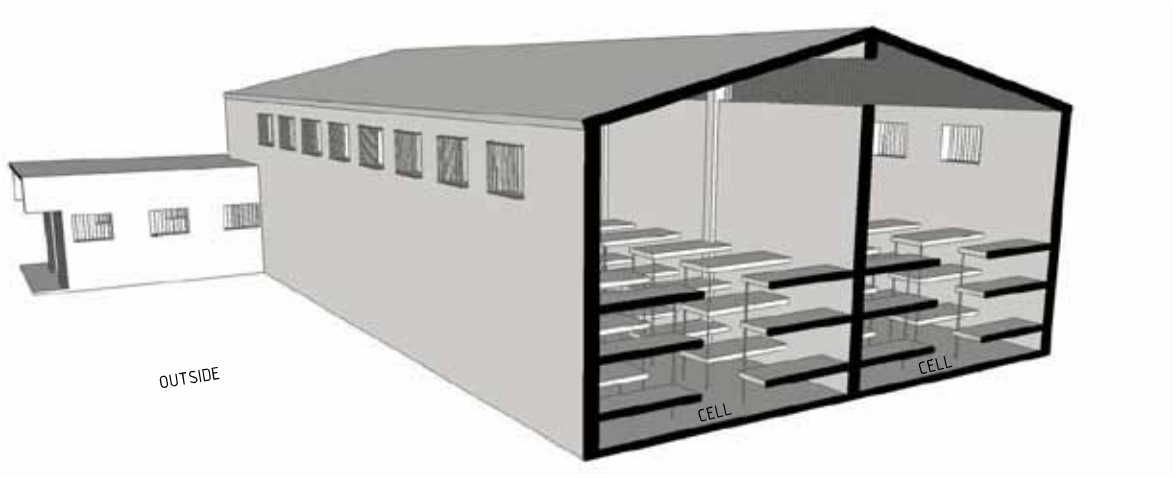
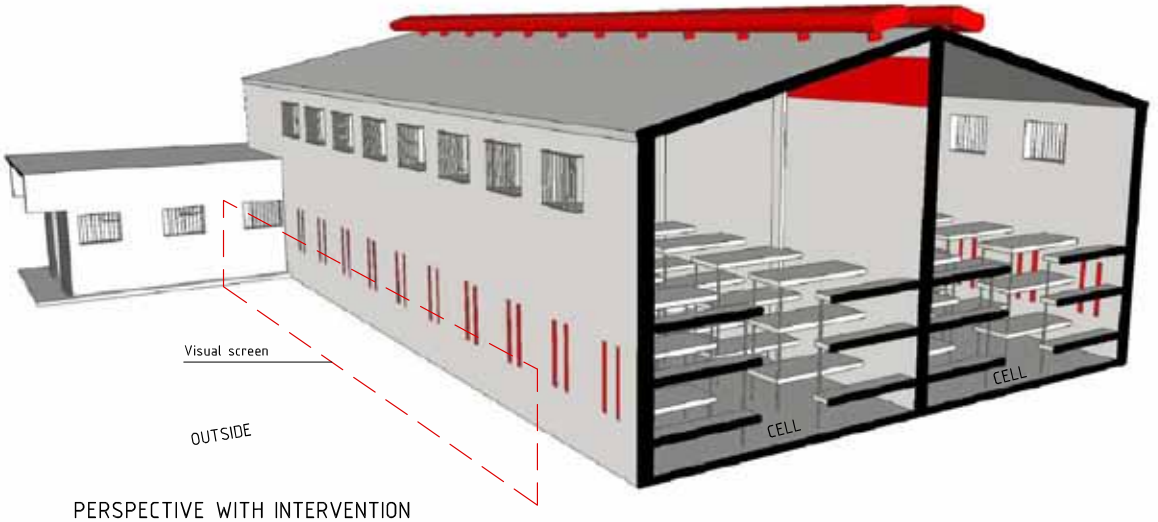


PERSPECTIVE WITHOUT INTERVENTION



PERSPECTIVE WITH INTERVENTION

CASE STUDY 5, CLASSROOM

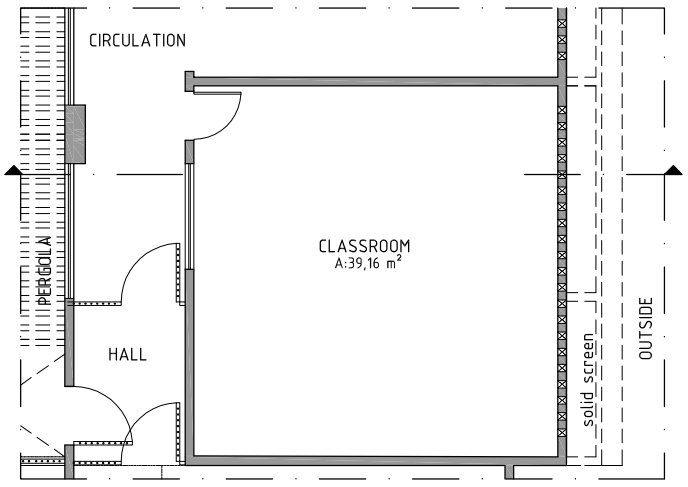
CLIMATE: Tropical – Part of the Northeast and Mid-West regions
The summer is hot and rainy, the winter hot and dry. Average temperatures over 20°C and annual temperature range of up to 7°C. Humidity varies throughout the year with periods of discomfort. The rainy season is well defined, alternating with dry periods. Wind speeds are higher in this climatic area. Attention needs to be paid to the thermal variations* during the different seasons and to the drop in air humidity.*

POSITIVE CHARACTERISTICS:

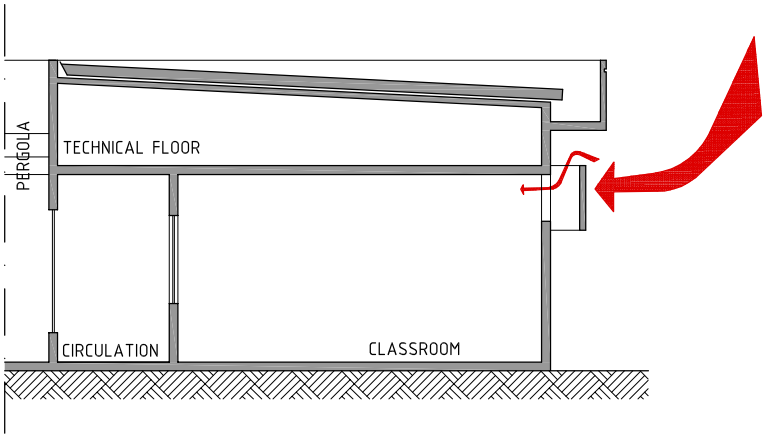
- The classroom presents the possibility of cross ventilation;
- The technical floor above the classroom provides protection against direct sunlight and overheating.

NEGATIVE CHARACTERISTICS:

- The entry of sunlight and ventilation is hampered by the presence of the solid screen* in front of the window;
- The combined surface of the ventilation openings facing the outside is far lower than recommended.



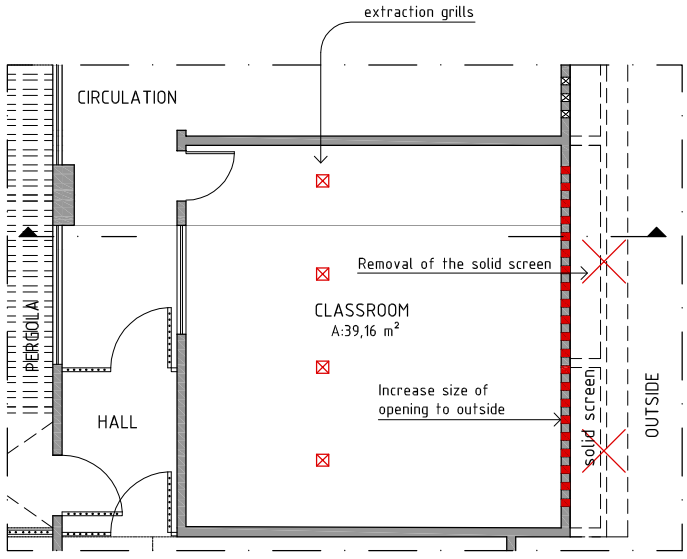
GROUND FLOOR PLAN
SCALE: 1/125



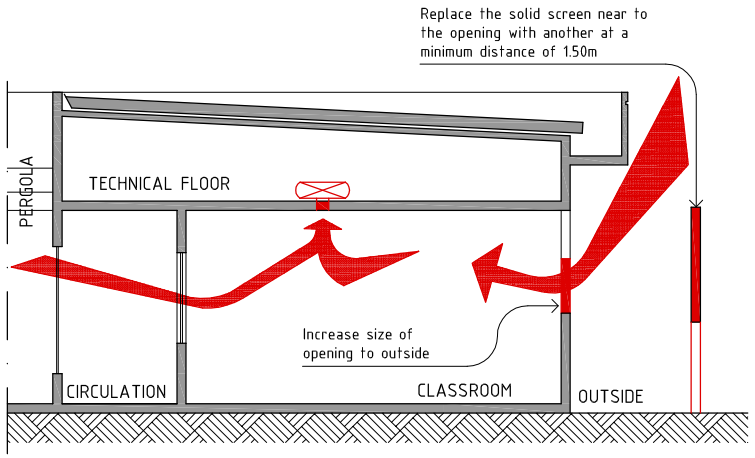
SECTION
SCALE: 1/125

INTERVENTIONS:

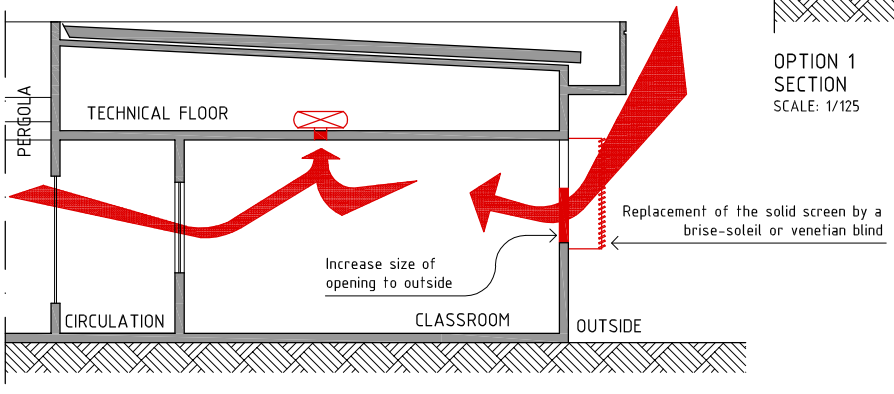
- When it is necessary to block the view, solid screens* should be used at a minimum distance of 1.5m from the window;
- Another option is the use of perforated screens* that block the view without blocking the entry of light and air, such as brise soleils* and venetian blinds;* it should be noted that in these cases, there is a reduction in air flow and the size of the windows should be increased accordingly;
- The opening for ventilation and illumination placed in the outside wall needs to be equivalent to 1/6 of the floor area of the classroom, especially given the high concentration of persons during classes;
- In locations where the wind regime is low, a mechanical air extraction system should be used.*



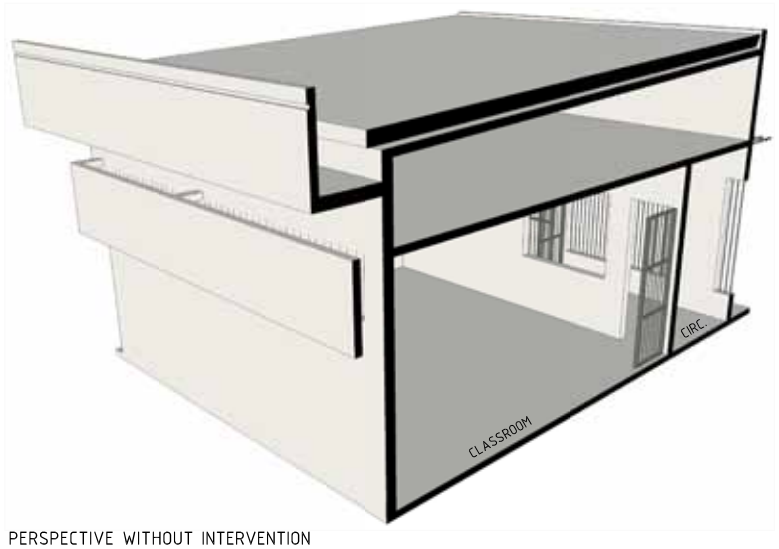
GROUND FLOOR PLAN
SCALE: 1/125



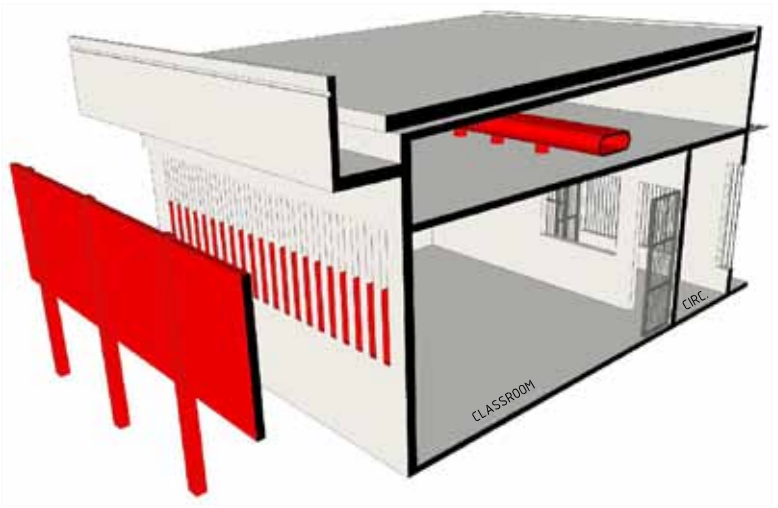
OPTION 1
SECTION
SCALE: 1/125



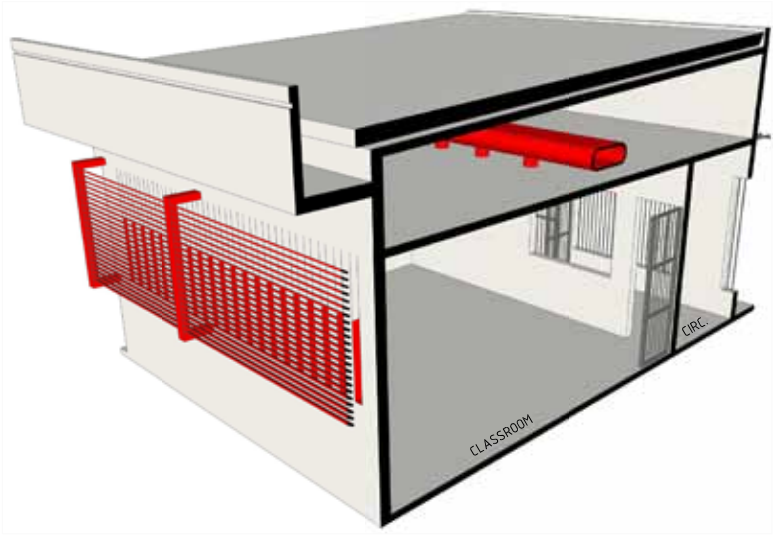
OPTION 2
SECTION
SCALE: 1/125



PERSPECTIVE WITHOUT INTERVENTION



PERSPECTIVE WITH INTERVENTION - OPTION 01



PERSPECTIVE WITH INTERVENTION - OPTION 02

CASE STUDY 6, MULTIUSE ROOM

CLIMATE: Tropical Atlantic or Maritime – Coastal region of the Northeast and Southeast

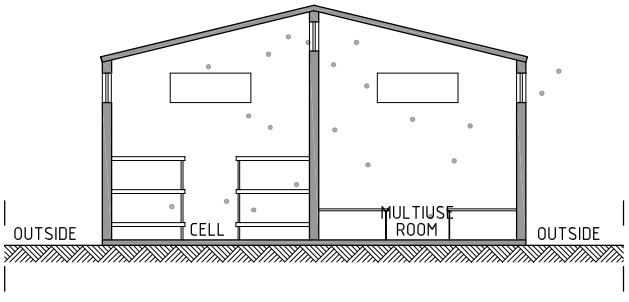
Seasonal cycle with little variation in the NE region. Higher thermal variations* in the SE region during autumn and winter. Variable relative air humidity* with uncomfortable periods during the summer. Intense rainfall in the summer in the SE region and during autumn and winter in the NE region. In the SE region, attention should be paid to the period of lower temperatures.

POSITIVE CHARACTERISTICS:

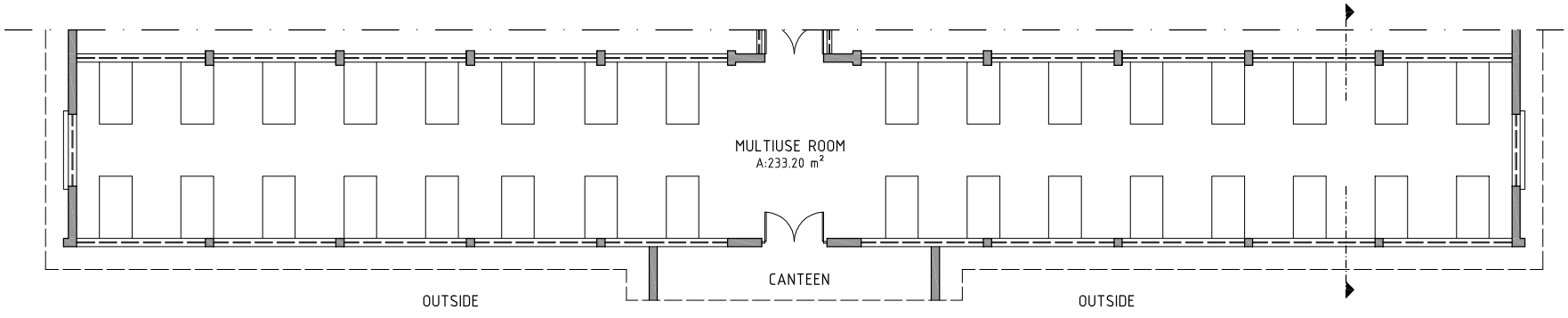
- The multiuse room has windows facing the outside on three of its sides, allowing cross ventilation;

NEGATIVE CHARACTERISTICS:

- The room is used in specific periods for activities with large concentrations of people, implying a high risk of contamination of the ambient;
- The size of window opening is less than 1/6 of the floor area;
- The window between the multiuse room and the dormitory next to it allows contaminated air to be exchanged between the two environments;
- The windows are located only in the upper part of the walls, which means that air circulation is inefficient at user height;
- The room lacks an air extraction system.



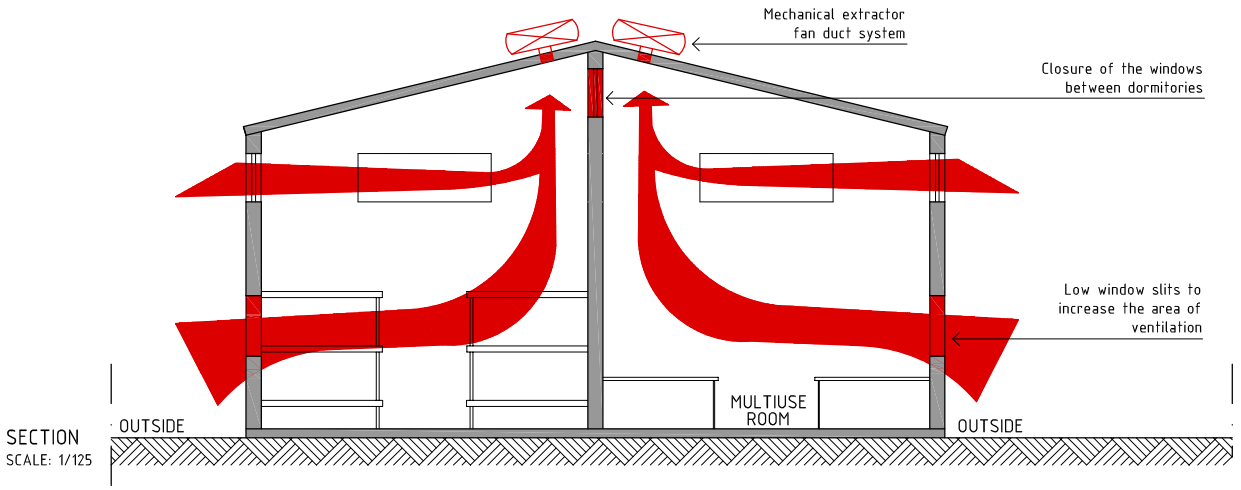
SECTION
SCALE: 1/200



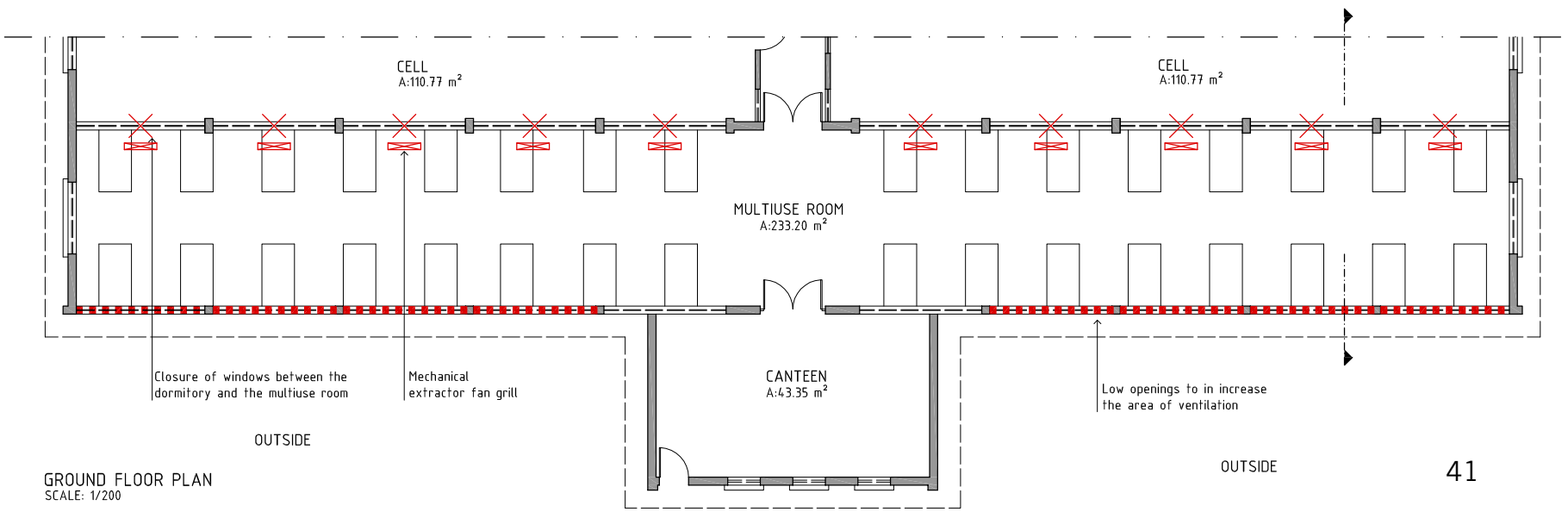
GROUND FLOOR PLAN
SCALE: 1/200

INTERVENTIONS:

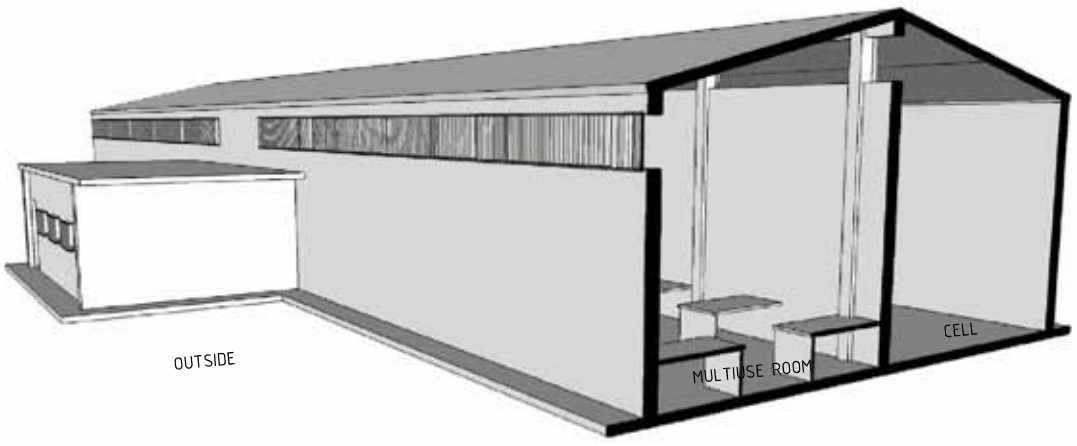
- Installation of a mechanical air extraction system* introduction of grills* on the wall opposite the windows;
- Introduction of vents, window slits* or low-level perforations to ensure the area open to the outside is equivalent to 1/6 of the floor area of the room and enable more even air circulation within the space;
- Closure of the vent between the cells and the multiuse room;
- Screens can be used if the view of the outside area compromises security.



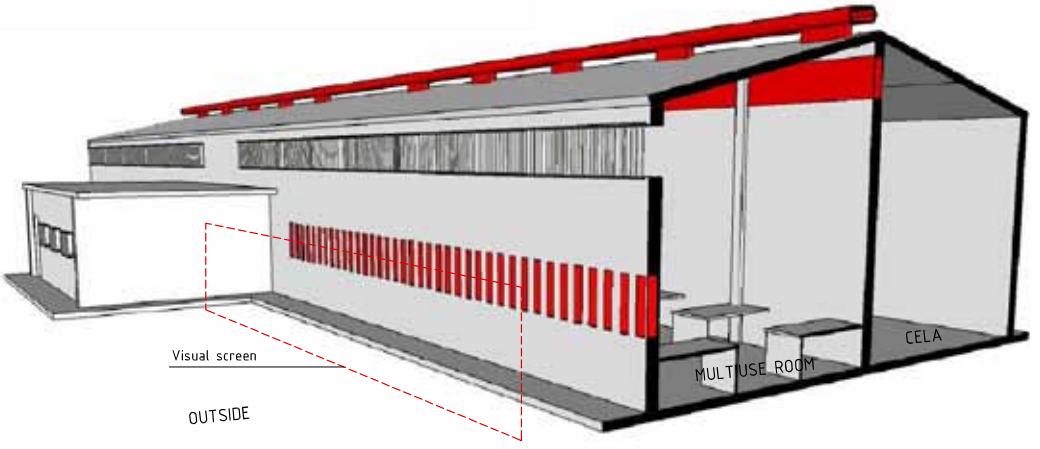
SECTION
SCALE: 1/125



GROUND FLOOR PLAN
SCALE: 1/200



PERSPECTIVE WITHOUT INTERVENTION



PERSPECTIVE WITH INTERVENTION

CASE STUDY 7, VISITING ROOM

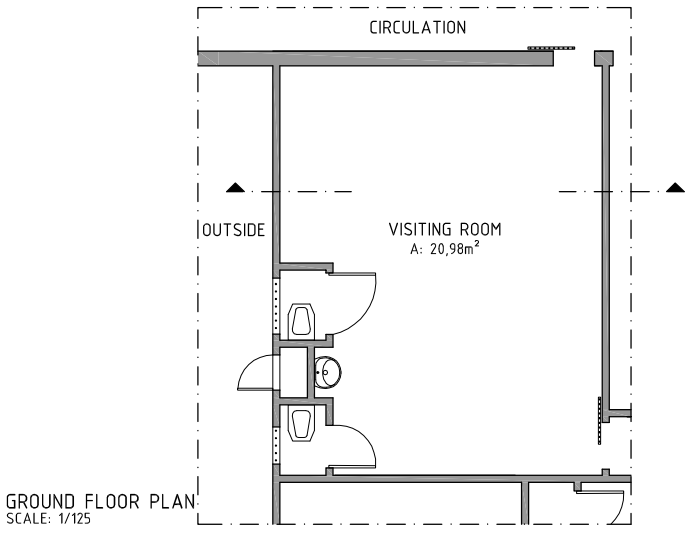
CLIMATE: Tropical – Part of the Northeast and Mid-West region
The summer is hot and rainy, the winter hot and dry. Average temperatures over 20°C and annual temperature range of up to 7°C. Humidity varies throughout the year with periods of discomfort. The rainy season is well defined, alternating with dry periods. Wind speeds are higher in this climatic area. Attention needs to be paid to the thermal variations* during the different seasons and to the drop in air humidity.*

POSITIVE CHARACTERISTICS:

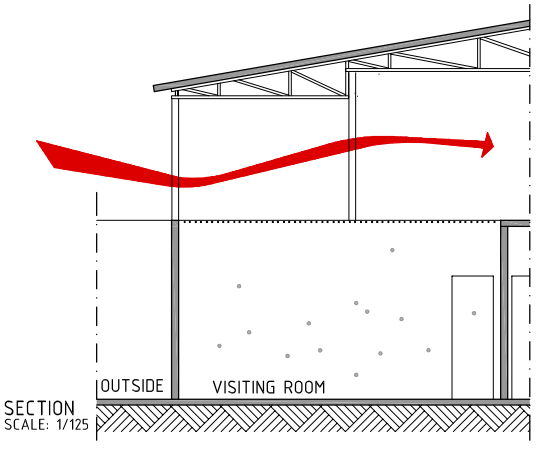
- The ventilation area in the roof allows large vents to be opened without compromising security;
- The raised roof with air circulating below produces good thermal conditions.

NEGATIVE CHARACTERISTICS:

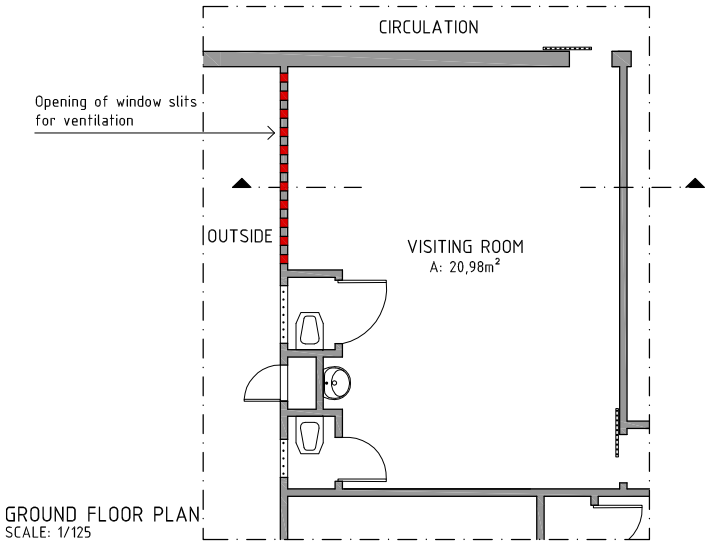
- Difficulties in achieving an even circulation of air in the visiting area, caused by the lack of vents in the lower part of the wall- for air to enter and/or screens* to direct the air downwards.



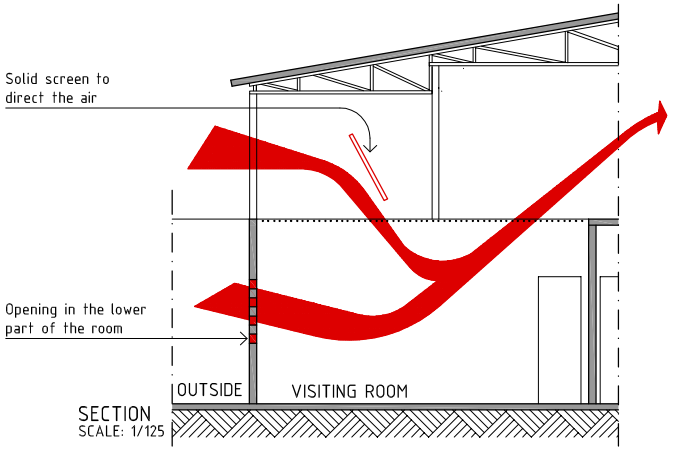
GROUND FLOOR PLAN
SCALE: 1/125



SECTION
SCALE: 1/125



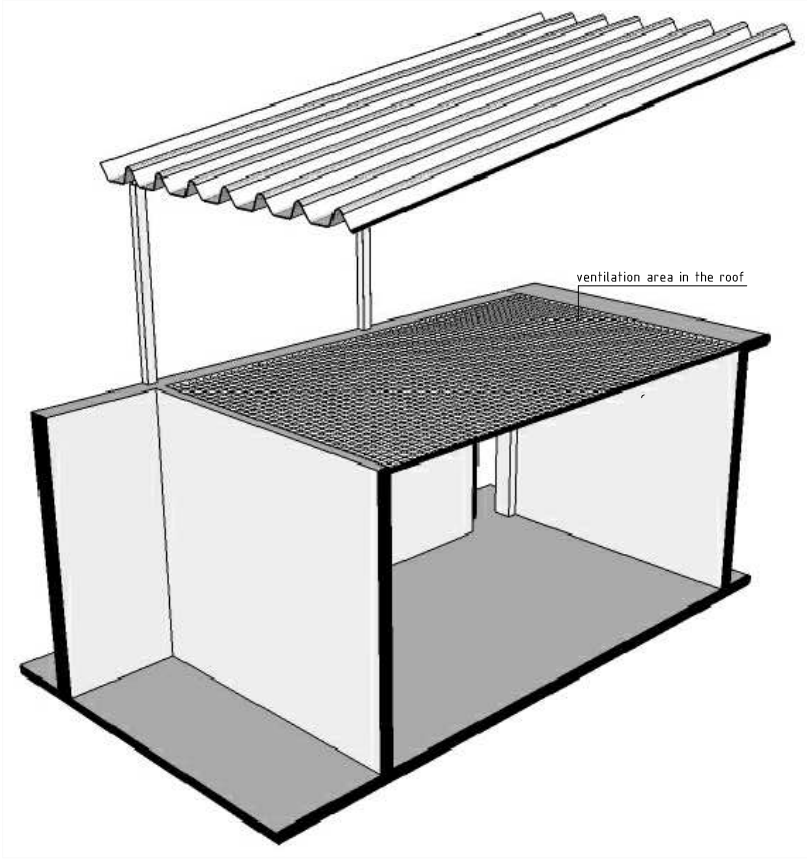
GROUND FLOOR PLAN
SCALE: 1/125



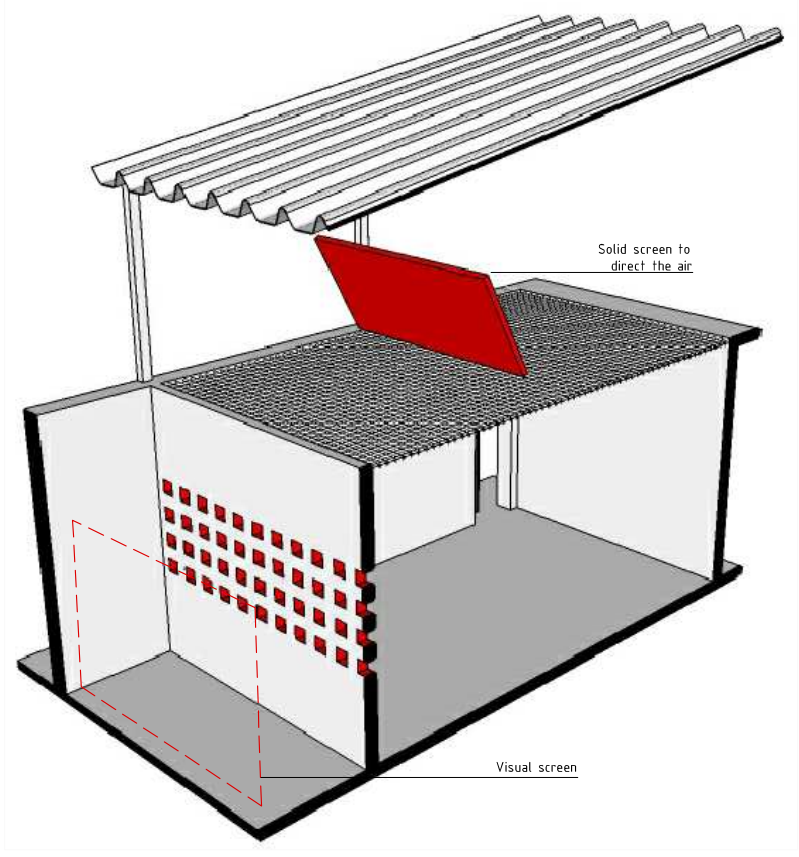
SECTION
SCALE: 1/125

INTERVENTIONS:

- Placement of screens* to direct the wind to induce air circulation in the lower part of the visiting room;
- Opening of low-level perforations or window slits* in the visiting room.



PERSPECTIVE WITHOUT INTERVENTION



PERSPECTIVE WITH INTERVENTION

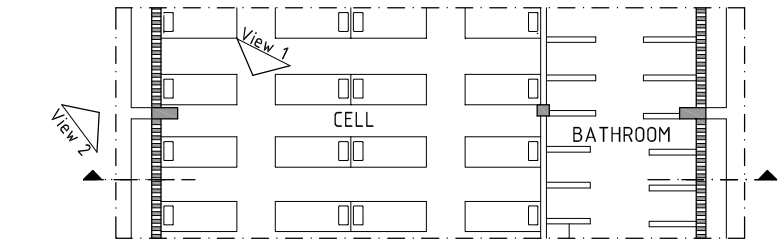
4. Good practices

In this chapter, we present examples of natural ventilation and illumination found in prisons of different Brazilian states. These examples, technically very simple, demonstrates that it is possible to solve envinronmental problems at low cost without compromising security.

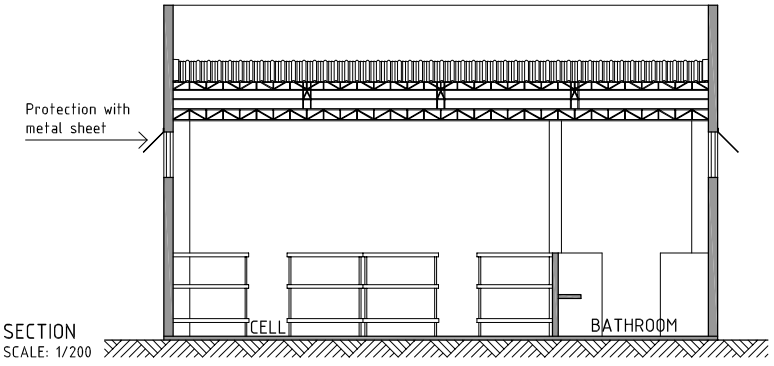
Each of these examples is in coherence with the type of inside and outside space, the use of these spaces, the length of time spent by the prisoners in these spaces, the level of security of the prison and the type of use of the space. These examples are applicable according to each case. It is important to observe, beyond the images, the principes on which these good solutions are based in order to be able to multiply these ideas and inspire new interventions adapted to the carachteristics of each environment.

PROTECTION OF FAÇADE OPENINGS

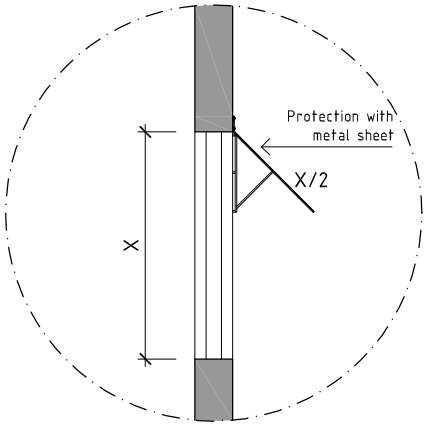
- The openings of the outside facades should be protected from direct sunlight and rain.



GROUND FLOOR PLAN
SCALE: 1/200



SECTION
SCALE: 1/200



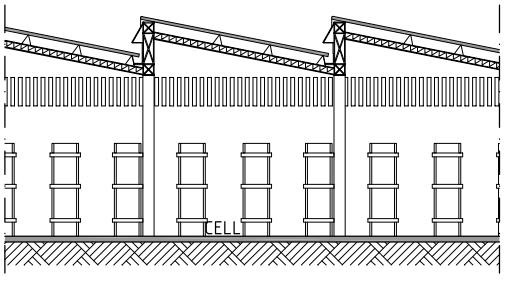
DETAIL
SCALE: 1/50

View 1 – Inside

View 2 – Outside

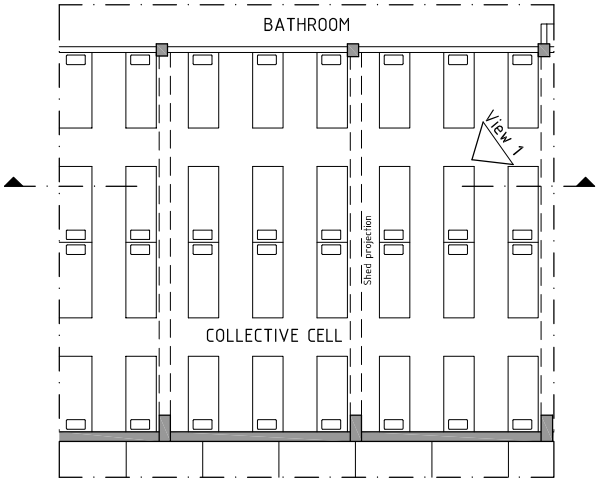
SHED

- The shed* solution, with an opening for ventilation, ensures the entry of natural sunlight, channelling of wind, air circulation and uniform illumination.
- Security observation: this solution should be used in locations with high ceilings such that a person standing on the highest bunk bed is unable to reach the ceiling. In closed prison regimen, bars should be fitted.

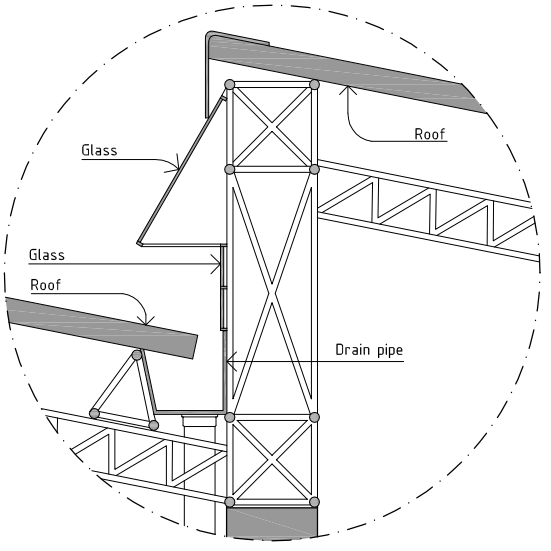


SECTION
SCALE: 1/200

Datail Shed



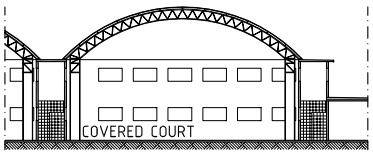
GROUND FLOOR PLAN
SCALE: 1/200



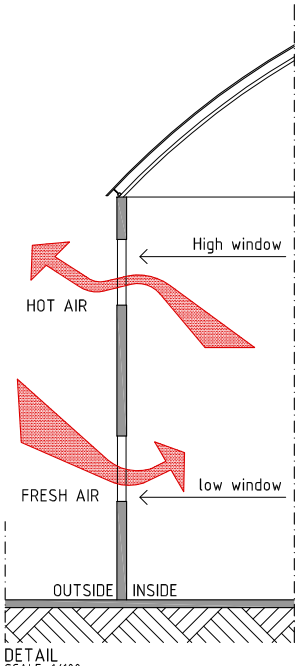
SECTION SHED
SCALE: 1/25

SPLIT-LEVEL VENTILATION

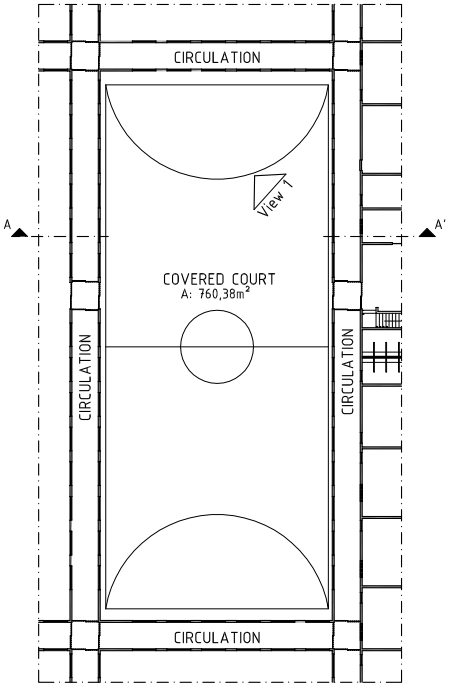
- Ventilation at multiple heights facilitates the entry of fresh air from below and the exit of warmer air above, inducing a more uniform circulation of air.



SECTION AA'
SCALE: 1/500

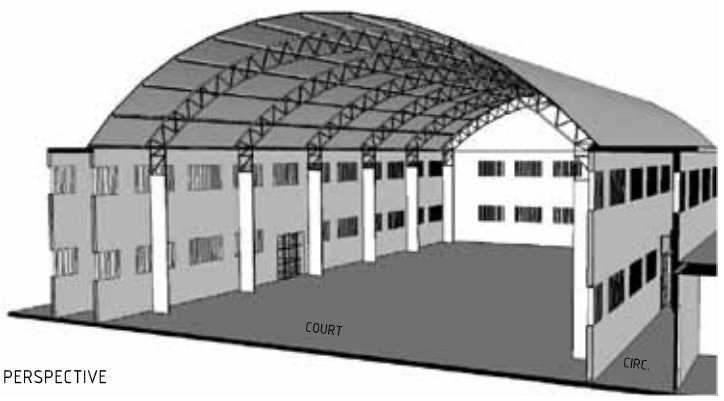


DETAIL
SCALE: 1/100



GROUND FLOOR PLAN
SCALE: 1/500

View 1



PERSPECTIVE

SLITS

- The use of window slits* enables security issues to be reconciled with the need for openings at user height, allowing the entry and more even distribution of light and air within the environment.

Window slits in classroom

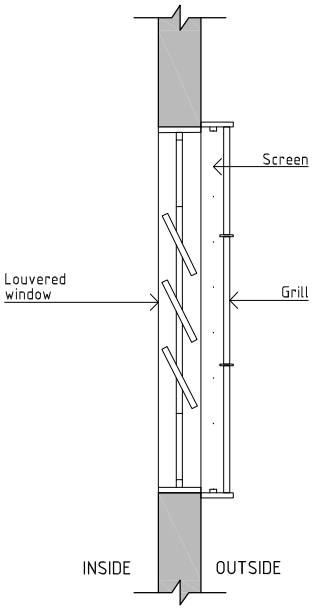

Window slits in the circulation


Window slits in cell pavilon


Window slits in the children play room

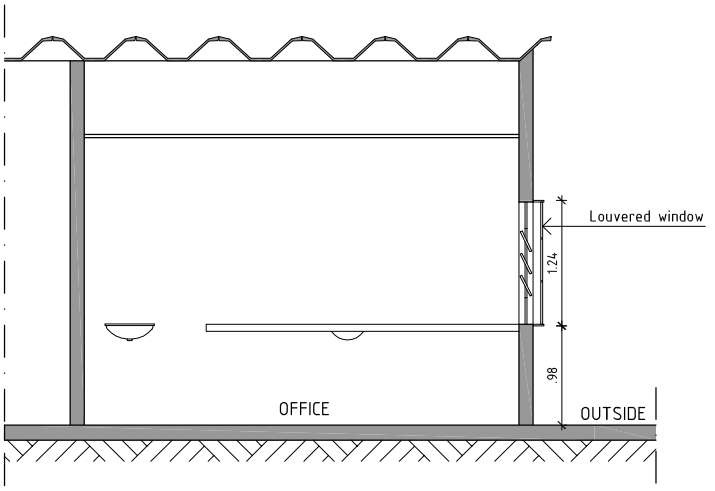
LOUVERED WINDOW WITH GRILL AND SCREEN

- Louvered windows allow a flexible response to the range of human needs and environmental situations. It contributes to improving the quality and healthiness of the environment without compromising security, thanks to the combination of grill and screen in a monitored environment.

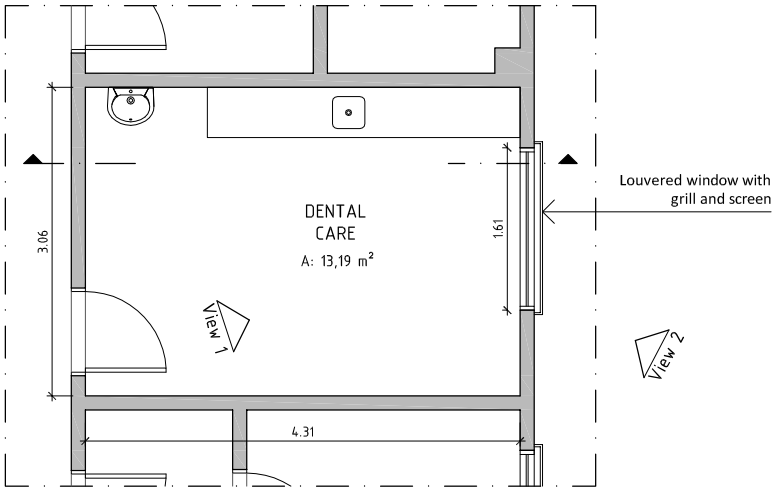


DETAIL
SCALE 1:25

View 2 – Window detail



SECTION
SCALE 1:75

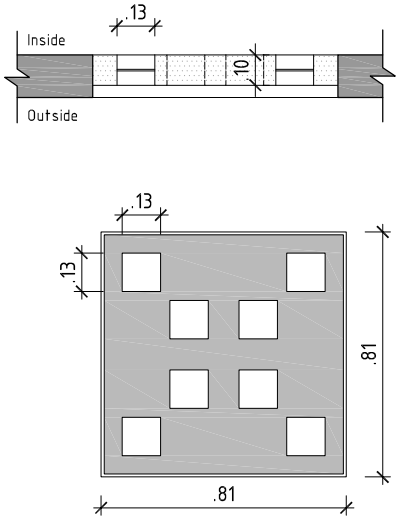


GROUND FLOOR PLAN
SCALE 1:75

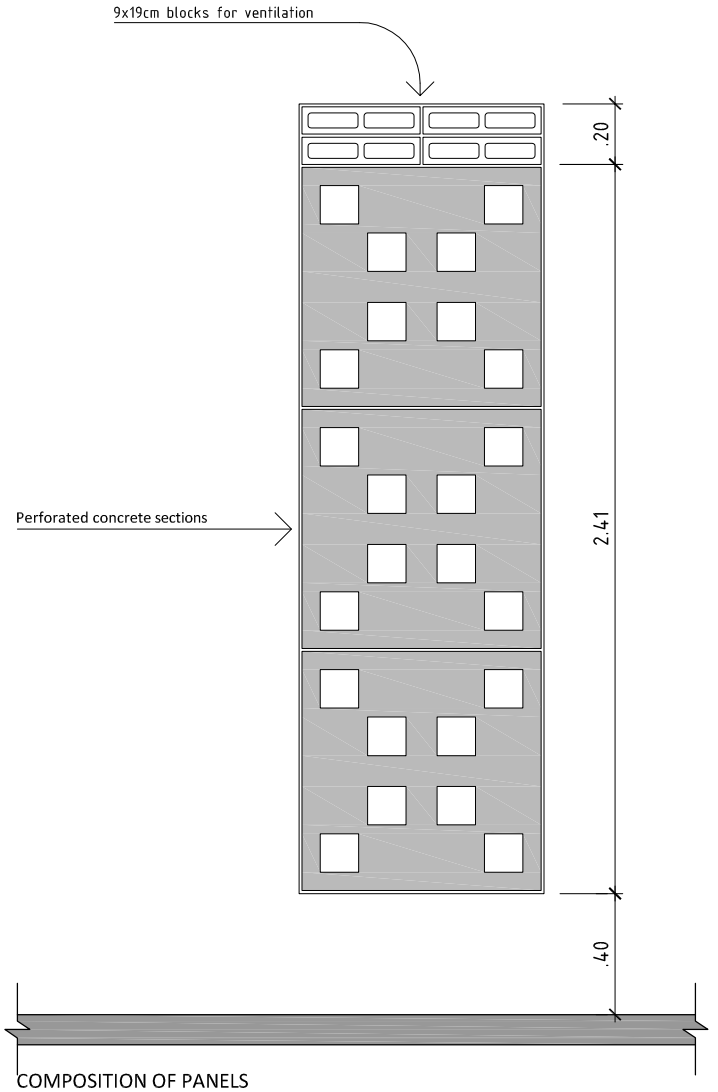
View 1 – Inside

PERFORATED CONCRETE SECTIONS

- Pre-shaped perforated concrete sections allow a wide range of design solutions and enable ventilation and illumination at various heights. As well as technical functions, they also add aesthetic value.



DETAIL
SCALE 1:25



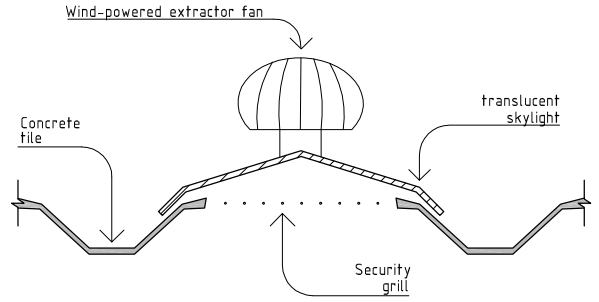
COMPOSITION OF PANELS
SCALE 1:25

Composition of panels in circulation area

Selection used for high ventilation

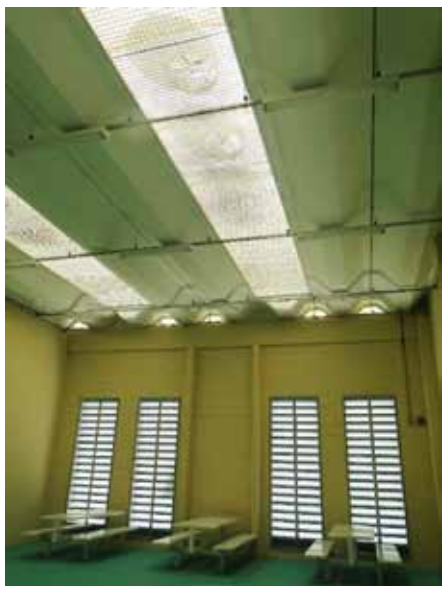
CONCRETE VENETIAN BLINDS AND SKYLIGHTS WITH BARS AND EXTRACTOR FAN

- Concrete Venetian blinds* allow natural ventilation at user height without enabling visual contact between the outside and inside and without compromising local security. However, this solution does reduce the amount of natural sunlight, which must therefore be captured in other ways.
- The design of a translucent skylight with a wind-powered extractor fan* and bars allows natural light to enter without compromising thermal comfort. The extractor fan solution in a space with low air inlets allows a more homogenous flow of air.

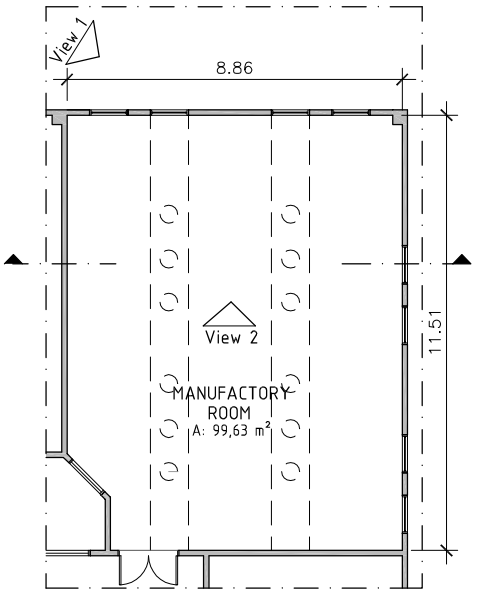


DETAIL 1
SKYLIGHT WITH BARS AND WIND-POWERED EXTRACTOR FAN
SCALE 1:50

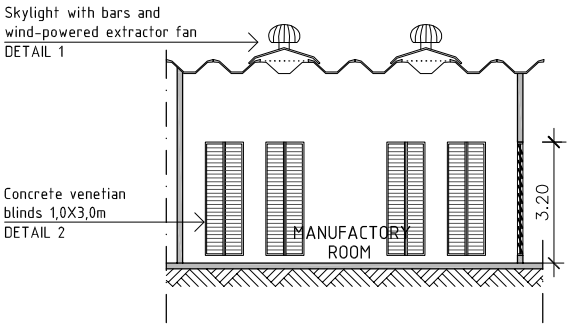
View 1 – Outside



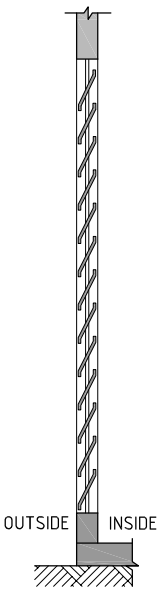
View 2 – Inside



GROUND FLOOR PLAN
SCALE 1:200



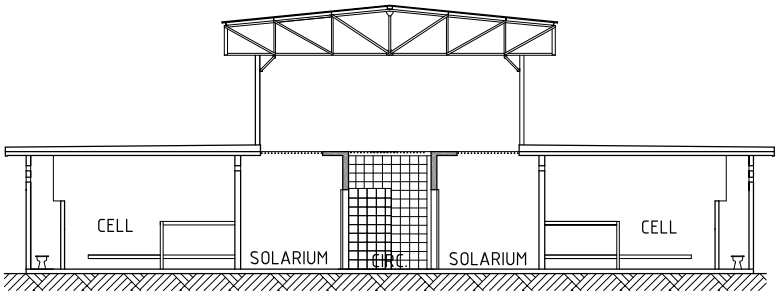
SECTION
SCALE 1:200



DETAIL 2
CONCRETE VENETIAN BLINDS
SCALE 1:50

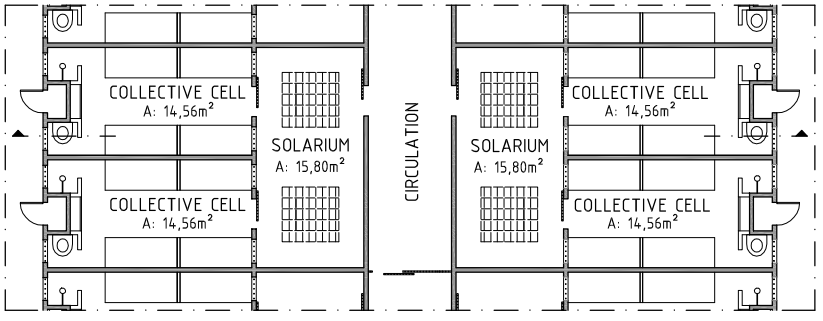
SOLARIUM IN CELLS

- Using an opening fitted with bars in the upper part of the space adjacent to the cell allows the creation of generous-sized vents without compromising security. Combined with the cell window and a door with bars, it allows cross ventilation and/or a stack effect.*

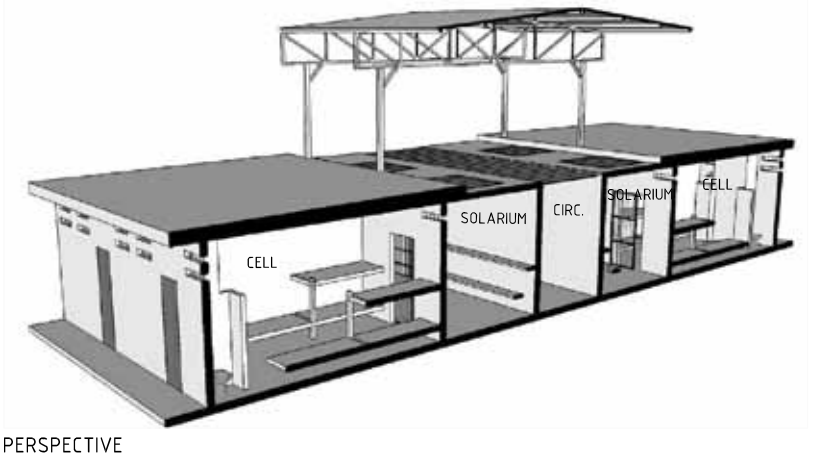


SECTION
SCALE: 1/125

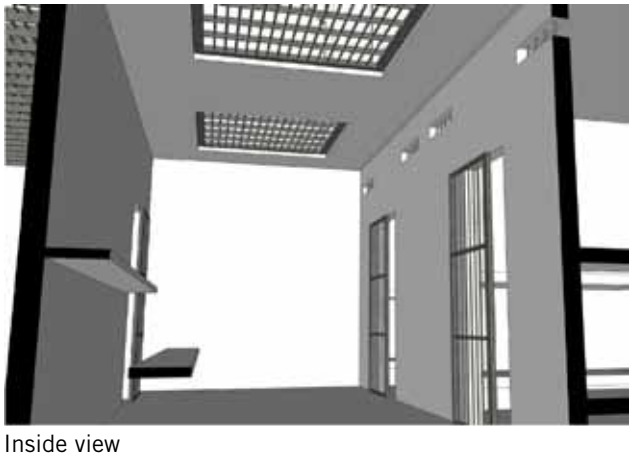
Top view



GROUND FLOOR PLAN
SCALE: 1/125



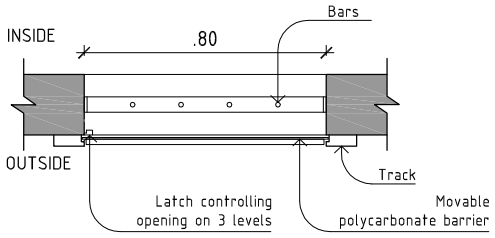
PERSPECTIVE



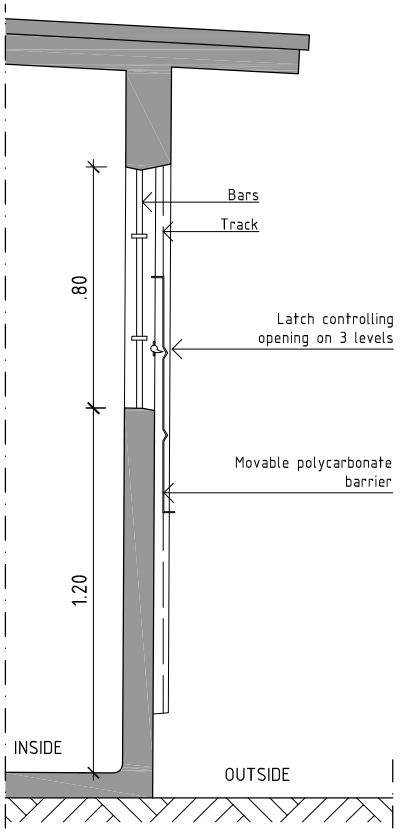
Inside view

WINDOW WITH MOVABLE VENTILATION BARRIER

- This model of window fitted with bars and a movable polycarbonate barrier, which allows the vent to be opened and closed, enables a flexible response to the range of human needs and environmental situations.



GROUND FLOOR PLAN
SCALE 1:25



SECTION
SCALE 1:25

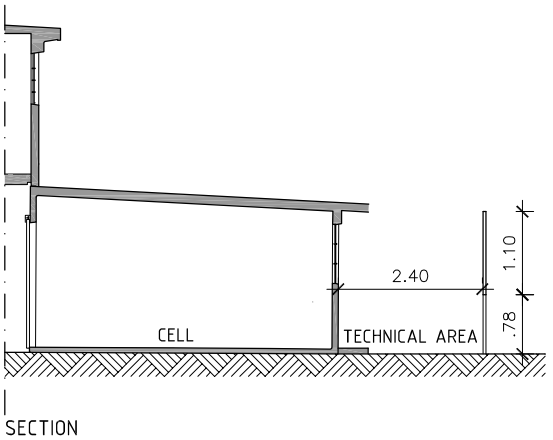
Inside view

Outside view

View detail

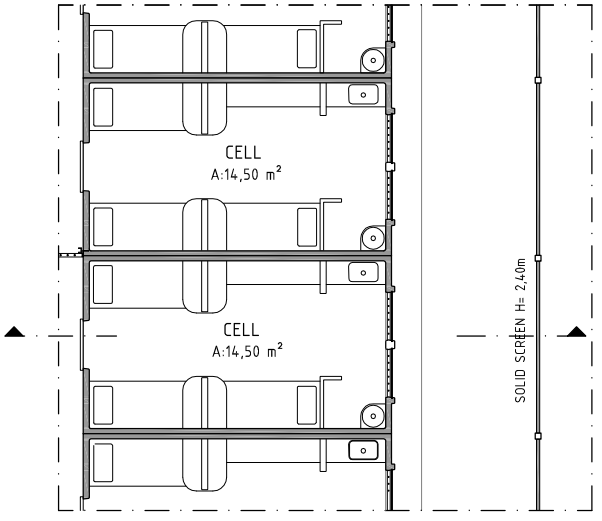
SCREEN

- Screen* solution for blocking visual contact between pavilions without compromising ventilation and illumination, allowing the cell windows to be opened more widely.



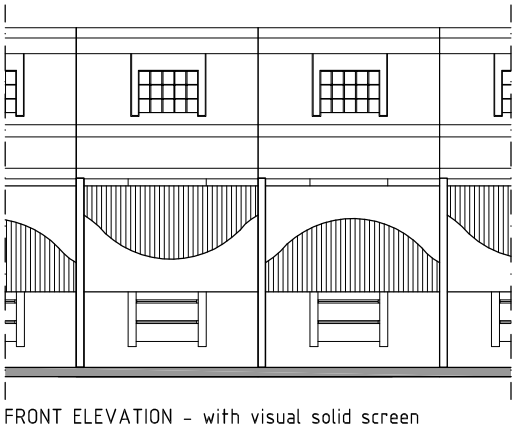
SECTION
SCALE: 1/100

Image of the outside



GROUND FLOOR PLAN
SCALE: 1/100

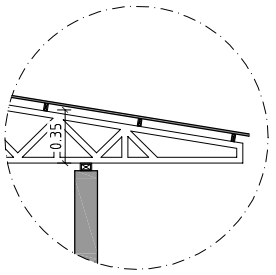
View 1 – Screen detail



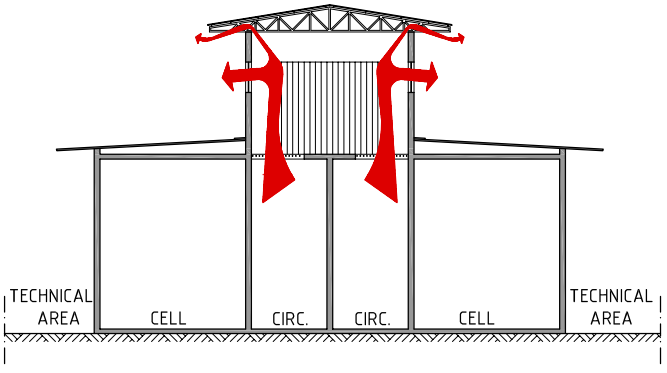
FRONT ELEVATION - with visual solid screen
SCALE: 1/100

SUSPENDED ROOF WITH SIDE OPENINGS

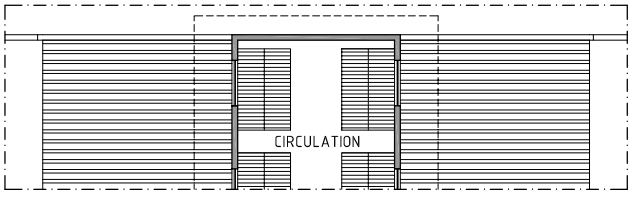
- The solution of raising the roof creates a vent between the roof and the wall, allowing the air to circulate between this vent and the windows, thus increasing the air circulation and helping to expel warmer air.



DETAIL
SCALE: 1/50



SECTION
SCALE: 1/200



GROUND FLOOR PLAN
SCALE: 1/200

View 1

View 1 – Window detail

Glossary

Air humidity – Quantity of water vapour present in the atmosphere, resulting from evaporation from water surfaces, vegetation and the soil.

Brise soleil – Screen composed of a series of elements, generally panels, placed in façades to provide shade from the sun. These elements may be mobile or fixed and placed horizontally or vertically.

Bunk bed – Two beds, one stacked on top of the other.

Cobogo – Perforated feature, typically made from ceramic or premoulded concrete, used in the fabrication of walls or wall sections.

Diffuse radiation – Transmission of the heat irradiated by the sun through cloud cover.

Domus – A dome-shaped skylight. Usually made from a fixed frame and tempered glass or lattices of aluminium and acrylic.

Ducts – Tube or tubing used to conduct fluid substances. The term is frequently applied to central air conditioning systems.

Grill – Placed primarily over openings to artificial air conductors in order to allow air to pass but blocking the view and access.

Mechanical extractor fan / Industrial fan – Equipment used to suck air out of the environment using an electrical motor.

Pergola – Wooden or brick structure arranged in rows of parallel columns to use as a shaded area or as support for climbing plants. Transparent sealing can be used on the framework to prevent rain entering when used as a shelter. However its original design function was to provide shade without obstructing ventilation.

Roof lantern – Composed of two sloping sections allowing light to enter from below and placed above the main roof ridge. Used to illuminate or ventilate the interior of the building.

Screen – Item placed in front of someone or something to provide seclusion or protection.

Shed – Cover with saw-shaped profile. Composed of alternating roof slopes and vertical transparent or translucentside panels, providing natural roof lighting. Sometimes constructed with venetian blinds, which allow wind capture.

Skylight – Opening in the roof covered by a transparent surface to allow or increase illumination and sometimes ventilation in compartments. Typically composed of a glazed frame.

Stack effect – In an environment where two openings are located on the wall and on the roof respectively, the difference in temperature between inside and outside induces a difference in pressure responsible for air circulation from the lower to the higher opening if there is sufficient distance between the two openings (at least two floors).

Thermal variation – Difference between maximum and minimum temperatures in an environment over a set period of time.

Triple bunk bed – Three beds stacked on top of each other.

Venetian blind – Screen made of sloping horizontal slats, allowing ventilation inside the building, blocking visibility and preventing rain from entering while shading the environment.

Window slit – Narrow and usually vertical opening made in walls. Allows increased illumination and sometimes ventilation inside the building. Its narrow size means it can be left open or covered using a frame fitted with glass or bars.

Wind-powered extractor fan – Equipment used to suck air out of the environment, functioning without the need for electrical power, making use of the displacement of atmospheric air and the convection effect of the internal air mass.

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Annex

FORM FOR ASSESSING ENVIRONMENTAL CONDITIONS FOR TUBERCULOSIS CONTROL IN PRISON UNITS

Objective and mode of utilization

The objective of this form is to enable a simplified assessment of the environmental quality of prison units in terms of ventilation and natural lighting. This assessment will serve as the basis for discussing and proposing architectural interventions aimed at reducing TB transmission. It is intended for prison administrations, civil society organizations involved in social monitoring of prisons, representatives of the Public Prosecutor's Office and of judges in charge of sentence application.

This evaluation should not be limited to the cells and places where prisoners remain during the day. It should also include the shared living spaces (schools, canteens, churches, etc.) and locales assigned for use by prison staff, especially guards. It does not include healthcare spaces which are evaluated by the health monitoring services and which must comply with the same norms as outside healthcare services.

This form comprises two sections: one with **general information** on the characteristics and structure of the evaluated prison unit, the other referring to the **environmental conditions** properly speaking, which should be completed for each of the evaluated areas (cells and other prison unit environments). Calculated using the detailed information gathered by the evaluator, the proposed **indicators** will enable a global assessment of environmental quality with the values considered satisfactory for each indicator being specified.

It is extremely important to use a general plan of the prison unit, designs and photos with comments by the evaluator in order to illustrate the environmental situations. This quantitative evaluation may be complemented by gathering information from people who stay in these spaces (especially prisoners and guards) in order to enable a simplified subjective evaluation of the environmental situation.

Form for assessing environmental conditions for tuberculosis control in prison units

Names/institution of visitors: _____

_____

Date of visit: _____

Characteristics of the Prison Unit (PU)

Name of the PU: _____ Year of inauguration: _____

Municipality: _____ State: _____ Email address of the directorate: _____

Localization: ( ) Metropolitan region ( ) Interior of state

Regime: ( ) Closed ( ) Semi-open ( ) Open Nível de segurança: ( ) High ( ) Medium

Population: ( ) Male ( ) Female ( ) Provisional ( ) Sentenced

Number (No) of TB cases during the previous year: _____ ( ) Unknown

No. of places: _____ No. of prisoners on day of visit: _____

Occupation rate: No. of prisoners on day of visit ÷ No. of places x 100 = _____ %

Example: A PU with a capacity for 500 prisoners (500 places) hosts 580 prisoners (real contingent). Hence: (580/500) x 100 = 116%. This means that in this PU, the number of prisoners exceeds its capacity by 16% (corresponding to 80 prisoners).

CONCLUSION ON OCCUPATION RATE: ( ) Adequate ( ) Inadequate

Prison Unit Structure

Individual Cells ( ) No ( ) Yes No. of individual cells: _____

Collective Cells ( ) No ( ) Yes No. of collective cells: _____ Average No. of prisoners per cell: _____

Communal Areas

Refectory: ( ) Yes ( ) No

Visiting area: ( ) Open area ( ) Closed area ( ) Mixed area

School: ( ) Yes ( ) No No. of classrooms: _____ No. of students per classroom: _____

Church: ( ) Yes ( ) No

Workshops: ( ) Yes ( ) No No. of workshops: _____ No. of persons per workshop: _____

Specific location for private visits: ( ) Yes ( ) No

Crèche: ( ) Yes ( ) No ( ) Not applicable

Healthcare area: ( ) Yes ( ) No

Rooms for use by lawyers: ( ) Yes ( ) No

Guard surveillance area: ( ) Yes ( ) No

Guard rest area: ( ) Yes ( ) No

Circulation area between cells (corridors) ( ) No openings ( ) With openings

( ) Circulation only ( ) Daytime use by prisoners

Survey of cell environment

1. Characteristics of Cell Openings (*only include doors, vents and windows that allow ventilation)*

	A	B	C	D	E	F	G	H
Opening	Type: window, vent, barred door	Height of opening	Width of opening	Area: height x width	Base height of window/ floor	Opening for: open, semi-open closed area*	Wall/building at less than 1.50 m from opening? Yes/No	Can the window be opened/ closed? Yes/No
1								
2								
3								
4								
5								

** Definition to be used: open area: internal courtyard, external area, other uncovered areas;*
semi-open area: solarium, verandah, etc;
closed area: other cell, closed corridor, communal use area.

(where possible, add drawings and/or photos)

2. Ratio between openings and cell area

Total area of openings (sum of values incolumn D*) = _____ m²
** omit openings for closed areas (see column F)*

Area of the cell's floor: length x width = _____ m²

CONCLUSION ON THE TOTAL CELL OPENING AREA:
( ) Adequate: equal to or higher than the sum of the cell's floor area ÷ 6 (1/6 of the floor area)
( ) Inadequate: less than the sum of the environment's floor area ÷ 6 (1/6 of the floor area)

3. Conditions for natural circulation of air *(where possible, add drawings and/or photos)*

Is there more than one opening (window, vent or door with open bars) in the cell? ( ) Yes ( ) No

If Yes (see pages 15 and 16 of the Manual of Environmental Interventions):
Is there cross-ventilation? ( ) Yes ( ) No
Is there split-ventilation (openings at two levels on the same wall)? ( ) Yes ( ) No
Do these openings allow the air to circulate at person's level? ( ) Yes ( ) No

Are there any obstacles to air circulation within the environment? ( ) Yes ( ) No

If Yes, what type of obstacle exists in the bed area?
Double or triple bunk beds in wall recesses ( ) Yes ( ) No
Double or triple bunk beds that do not allow a person room to sit up properly ( ) Yes ( ) No
Fabric or other material separating the beds ( ) Yes ( ) No
Bathroom walls blocking air circulation ( ) Yes ( ) No
Other obstacles: _____

CONCLUSION ON THE NATURAL AIR CIRCULATION CONDITIONS: ( ) Adequate ( ) Inadequate

4. Mechanical ventilation *(where possible, add drawings and/or photos)*

Note: Mechanical ventilation refers to systems that extract air (by suction) and systems that blow air (commonly called fans); the same principles of air circulation apply to both.

Are cells fitted with some type of mechanical ventilation: ( ) Yes ( ) No

If Yes:

( ) Wind-powered extraction equipment ( ) Individual air extraction equipment

( ) Networked air extraction system ( ) Individual air blowing equipment (fan)

( ) Networked air blowing (fan) system

Does the system used *(see page 22 of the Manual of Environmental Interventions Manual)*:

1. force the clean air to take the longest route possible through the cell? ( ) Yes ( ) No
2. avoid the transmission of contaminated air to other areas used for circulation, activities or rest? ( ) Yes ( ) No
3. allow air to circulate at person's level? ( ) Yes ( ) No

Note: If possible include data on the system equipment and installation design.

CONCLUSION ON THE MECHANICAL VENTILATION CONDITIONS: ( ) Non-existent ( ) Exists but does not function ( ) Exists and functions

If the system functions: ( ) Adequately ( ) Inadequately

5. Natural Lighting

Does artificial lighting need to be used during the daytime? ( ) Yes ( ) No

Does the natural lighting reach most of the environment's area? ( ) Yes ( ) No

CONCLUSION ON NATURAL LIGHTING: ( ) Adequate ( ) Inadequate

6. Cell Occupation Level

No. of prisoners: _____ Width: _____ m Length: _____ m Height: _____m

Area per prisoner = Area of cell (length x width) / No.of prisoners = _____m^2

Reference value: 6m^2 per prisoner in individual cells and a minimum of 2m^2 per prisoner in collective cells

Example: A cell 20m long by 5m wide (100 m^2) holds 75 prisoners. Therefore: 100m^2/75 prisoners = 1.33m^2 per prisoner. This means that in this cell, the area available to each prisoner is lower than the reference value (2m^2/prisoner), indicating a cell occupation over its capacity.

CONCLUSION ON CELL OCCUPATION LEVEL: ( ) Adequate ( ) Inadequate

FINAL CONCLUSION: _____

_____

_____

_____

_____

Survey of other prison unit environments

Name of the environment: _____ Average number of users: _____

Environment with a high concentration of people? ( ) Yes ( ) No

Average time spent in the environment: ( ) up to 1h ( ) 1h to 5h ( ) over 5h

Width: _____ m Length: _____ m Height: _____ m

Environment: ( ) Closed ( ) Open with cover ( ) Open without cover

1. Characteristics of Environment Openings *(only include doors, vents and windows that allow ventilation)*

	A	B	C	D	E	F	G	H
Opening	Type: window, vent, barred door	Height of opening	Width of opening	Area: height x width	Base height of window/ floor	Opening for: open, semi-open closed area*	Wall/building at less than 1.50 m from opening? Yes/No	Can the window be opened/ closed? Yes/No
1								
2								
3								
4								
5								

** Definition to be used: open area: internal courtyard, external area, other covered areas;*
semi-open area: solarium, verandah, etc;
closed area: other cell, closed corridor, communal use area.
(if possible, add drawings and/or photos)

2. Ratio between openings and floor area

Total area of openings (sum of values in column D*) = _____ m²
** omit openings for closed areas (see column F)*

Floor area: length x width = _____ m²

CONCLUSION ON THE TOTAL AREA OF OPENINGS:
( ) Adequate: equal to or higher than the sum of the environment's floor area ÷ 6 (1/6 of the floor area)
( ) Inadequate: less than the sum of the environment's floor area ÷ 6 (1/6 of the floor area)

3. Conditions for natural circulation of air *(where possible, add drawings and/or photos)*

Is there more than one opening (window, vent or door with open bars) in the environment? ( ) Yes ( ) No
If Yes (*see pages 15 and 16 of the Manual of Environmental Interventions*):
Is there cross-ventilation? ( ) Yes ( ) No
Is there split-ventilation (openings at two levels on the same wall)? ( ) Yes ( ) No

Do these openings allow the air to circulate at person's level? ( ) Yes ( ) No

Are there any obstacles to air circulation within the environment? ( ) Yes ( ) No

If Yes, what type of obstacle: _____

CONCLUSION ON NATURAL AIR CIRCULATION CONDITIONS: ( ) Adequate ( ) Inadequate

4. Mechanical ventilation *(where possible, add drawings and/or photos)*

Note: Mechanical ventilation refers to systems that extract air (by suction) and systems that blow air (commonly called fans); the same principles of air circulation apply to both.

Is the environment fitted with some type of mechanical ventilation: ( ) Yes ( ) No

If Yes:

( ) Wind-powered extraction equipment
( ) Networked air extraction system
( ) Networked air blowing (fan) system
( ) Individual air extraction equipment
( ) Individual air blowing equipment (fan)

Does the system used *(see pages 22 and 23 of the Manual of Environmental Interventions):*

1. force the clean air to take the longest route possible through the environment? ( ) Yes ( ) No
2. avoid the transmission of contaminated air to other areas used for circulation, activities or rest? ( ) Yes ( ) No
3. allow air to circulate at person's level? ( ) Yes ( ) No

Note: If possible include data on the system equipment and installation design.

CONCLUSION ON THE MECHANICAL VENTILATION CONDITIONS: ( ) Non-existent ( ) Exists but does not function ( ) Exists and functions
If the system functions: ( ) Adequately ( ) Inadequately

5. Natural Lighting

Does artificial lighting need to be used during the daytime? ( ) Yes ( ) No
Does the natural lighting reach most of the environment's area? ( ) Yes ( ) No
Conclusion on natural lighting: ( ) Adequate ( ) Inadequate

FINALCONCLUSION: _____
_____
_____
_____
_____

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