



CAMOC / ICAMT join session :
Museums between their
collections and their
environments

Environmental Sustainability in Museum Architecture in Previously Existing Buildings: Tools for Decision-Making

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and
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In Brazil the interest in museums is growing steadily, and in the beginning of the century it achieved significant importance, that led to the creation of a specific body to take care of the Brazilian museums, the Brazilian Institute of Museums / IBRAM



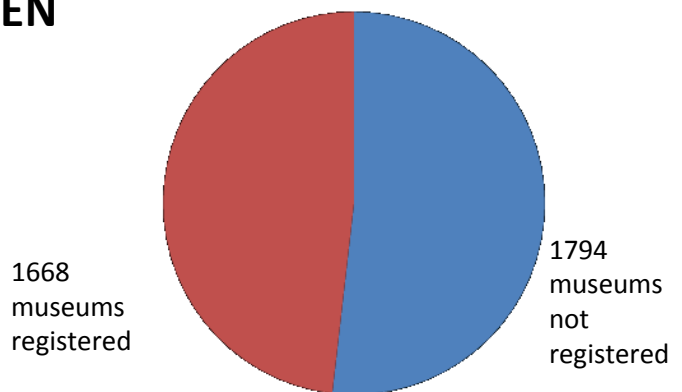
In 1818 it was created the first museum in Brazil, the Royal Museum, which was installed in existing buildings in the city of Rio de Janeiro.

In 1892 the museum was installed in the old imperial residence, which was unoccupied, in alignment with the preservation policy and European politics of national identity.

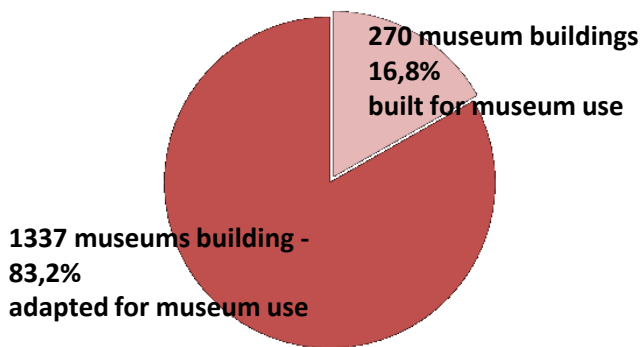


3462 MUSEUMS HAVE BEEN IDENTIFIED IN BRAZIL

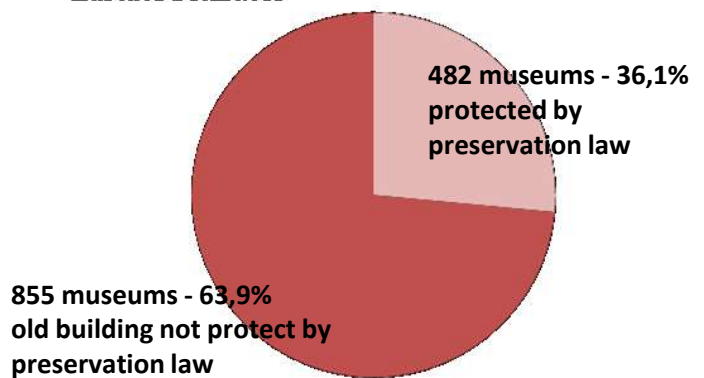
CNM / IBRAM / MinC
October of 2013



1607 MUSEUMS HAVE REPORTED ABOUT THEIR BUILDINGS



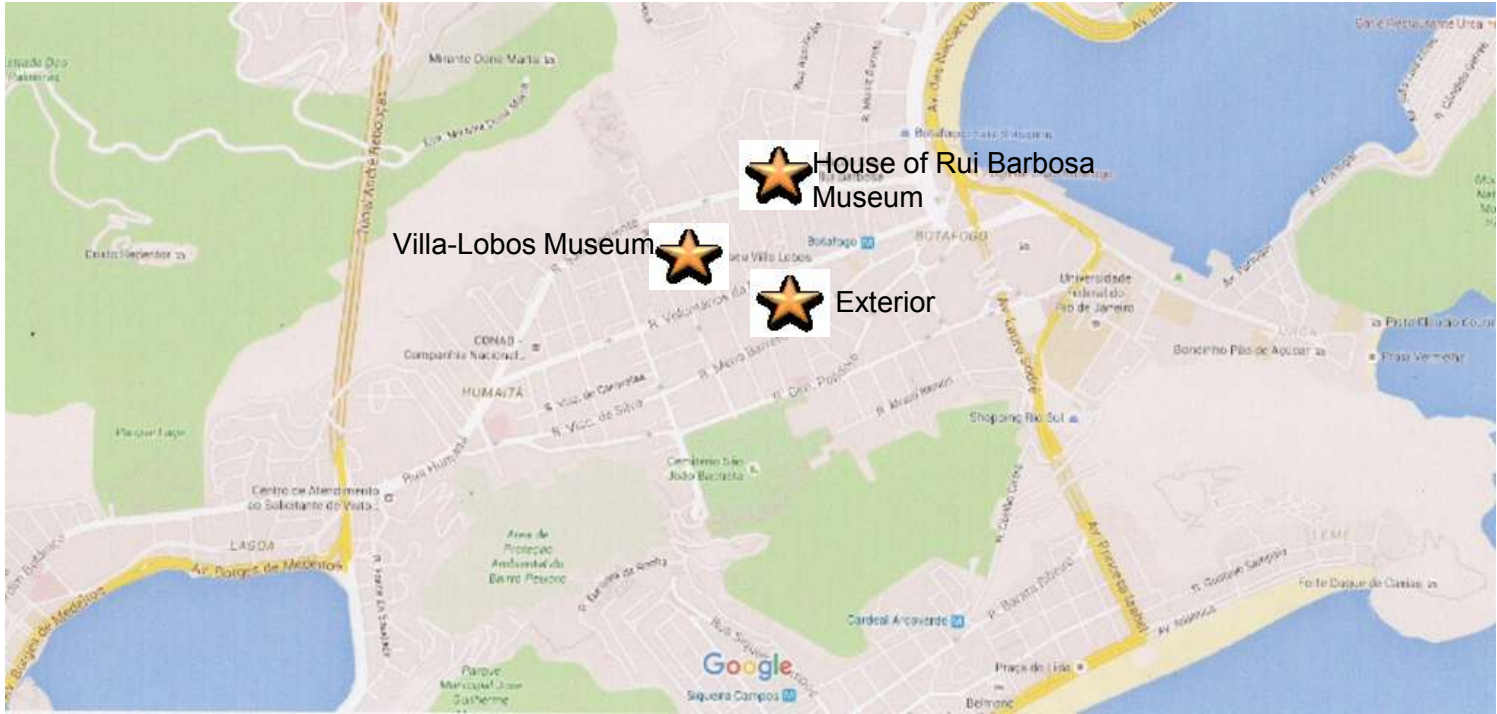
1337 MUSEMS REPORTED ABOUT THEIR PREVIOUSLY EXISTING BUILDINGS

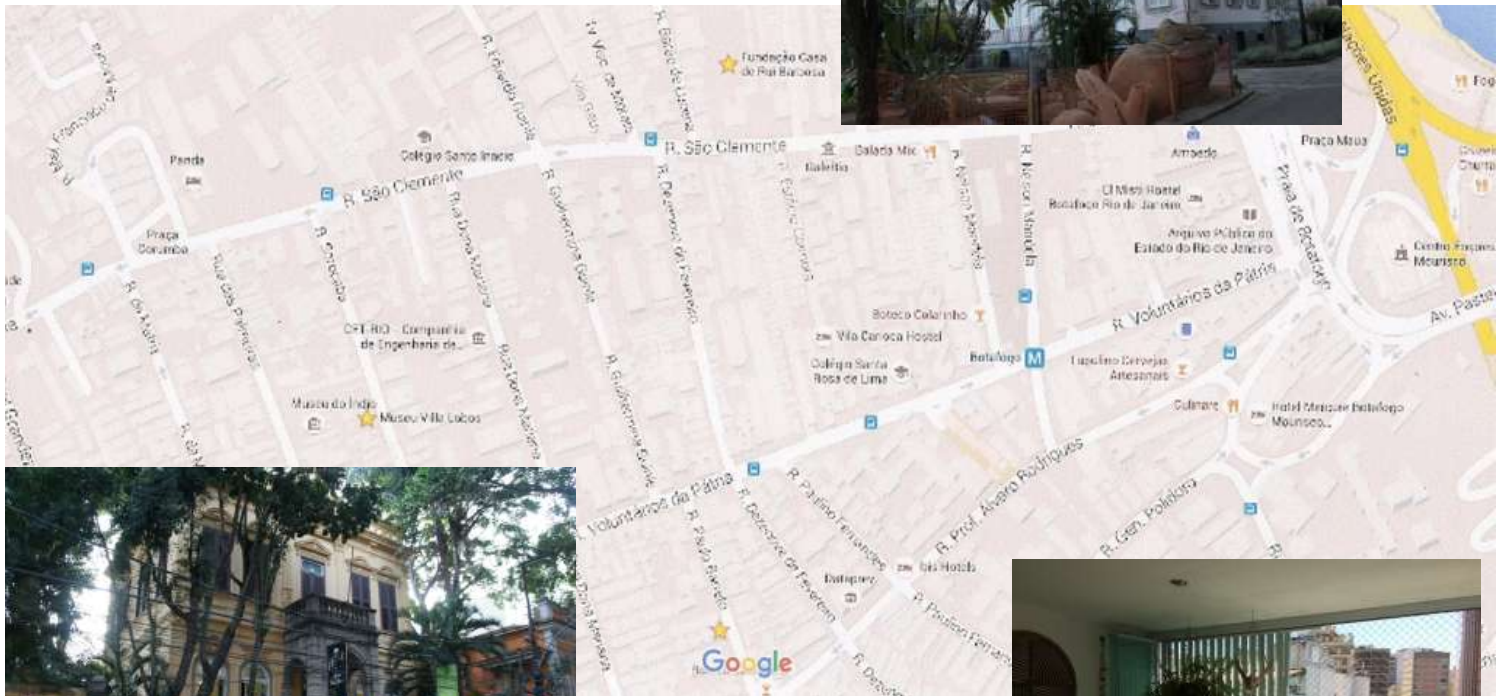


To understand the architecture of museums that has been produced in Brazil since the early nineteenth century, it is necessary to know the different levels of connection between museums and existing buildings.

In Brazil the adjustments undertaken in the old museum building begin to develop sustainable practices and use bioclimatic strategies in the search for human comfort conditions and environmental control for collections.

Botafogo neighborhood - city of Rio de Janeiro - Brazil







Both museums are installed in historic buildings adapted for museum use.



We have used the example of historic buildings, because they are the most restrictive.



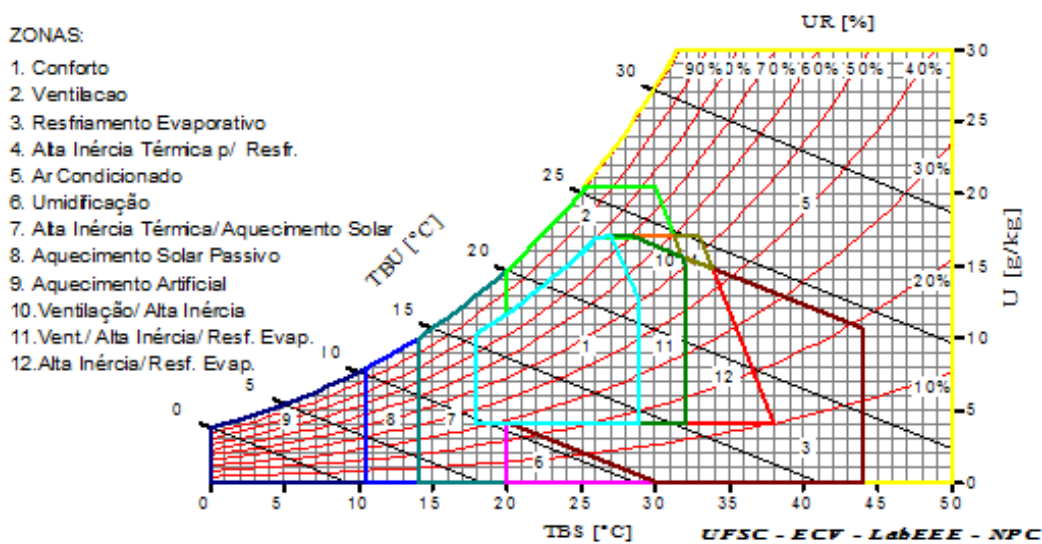


We have performed temperature, relative humidity and lighting measurements in the three places, with one hour interval and over the period of one year.

HOBO data logger U12-012

| ANO 2018 | MES MARCH | DATA 01/03/2018 | VILA LOBOS MUSEUM | | | CASA DE RUI BARBOSA MUSEUM | | | EXTERIOR | | |
|----------|-----------|-----------------|-------------------|--------|----------------|----------------------------|--------|----------------|------------------|--------|----------------|
| | | | Temperature (°C) | RH (%) | Lighting (lux) | Temperature (°C) | RH (%) | Lighting (lux) | Temperature (°C) | RH (%) | Lighting (lux) |
| | | 00:00 | 28.11 | 61.10 | 19.00 | 23.90 | 57.40 | 30.00 | 27.91 | 61.10 | 21.00 |
| | | 01:00 | 28.11 | 62.10 | 18.00 | 25.90 | 57.40 | 30.00 | 27.91 | 62.40 | 21.00 |
| | | 02:00 | 27.81 | 62.10 | 18.00 | 25.90 | 56.90 | 30.00 | 27.91 | 62.70 | 21.00 |
| | | 03:00 | 27.81 | 61.70 | 18.00 | 25.90 | 56.70 | 30.00 | 27.91 | 63.10 | 21.00 |
| | | 04:00 | 27.81 | 61.10 | 18.00 | 26.90 | 56.00 | 30.00 | 27.91 | 63.00 | 21.00 |
| | | 05:00 | 27.81 | 60.10 | 18.00 | 28.30 | 55.00 | 30.00 | 27.51 | 61.40 | 21.00 |
| | | 06:00 | 27.81 | 60.80 | 18.00 | 29.50 | 54.00 | 30.00 | 27.11 | 60.00 | 21.00 |
| | | 07:00 | 27.91 | 60.40 | 18.00 | 29.10 | 54.00 | 30.00 | 26.70 | 58.90 | 21.00 |
| | | 08:00 | 27.81 | 59.50 | 18.00 | 28.10 | 53.10 | 30.00 | 26.30 | 57.90 | 21.00 |
| | | 09:00 | 27.81 | 57.20 | 18.00 | 26.10 | 54.00 | 30.00 | 25.90 | 56.90 | 21.00 |
| | | 10:00 | 27.81 | 56.50 | 18.00 | 25.10 | 54.00 | 30.00 | 25.50 | 55.90 | 21.00 |
| | | 11:00 | 27.81 | 57.70 | 18.00 | 23.10 | 53.00 | 30.00 | 25.10 | 54.90 | 21.00 |
| | | 12:00 | 27.91 | 58.10 | 18.00 | 21.10 | 53.00 | 30.00 | 24.70 | 53.90 | 21.00 |
| | | 13:00 | 27.91 | 58.10 | 18.00 | 19.10 | 53.00 | 30.00 | 24.30 | 52.90 | 21.00 |
| | | 14:00 | 27.91 | 58.10 | 18.00 | 17.10 | 53.00 | 30.00 | 23.90 | 51.90 | 21.00 |
| | | 15:00 | 27.91 | 57.70 | 18.00 | 15.10 | 53.00 | 30.00 | 23.50 | 50.90 | 21.00 |
| | | 16:00 | 27.91 | 56.70 | 18.00 | 13.10 | 53.00 | 30.00 | 23.10 | 49.90 | 21.00 |
| | | 17:00 | 27.91 | 56.90 | 18.00 | 11.10 | 53.00 | 30.00 | 22.70 | 48.90 | 21.00 |
| | | 18:00 | 27.91 | 57.70 | 18.00 | 9.10 | 53.00 | 30.00 | 22.30 | 47.90 | 21.00 |
| | | 19:00 | 27.91 | 58.10 | 18.00 | 7.10 | 53.00 | 30.00 | 21.90 | 46.90 | 21.00 |
| | | 20:00 | 27.52 | 58.00 | 18.00 | 5.10 | 53.00 | 30.00 | 21.50 | 45.90 | 21.00 |
| | | 21:00 | 27.52 | 59.30 | 18.00 | 3.10 | 53.00 | 30.00 | 21.10 | 44.90 | 21.00 |
| | | 22:00 | 27.12 | 60.00 | 18.00 | 1.10 | 53.00 | 30.00 | 20.70 | 43.90 | 21.00 |
| | | 23:00 | 27.12 | 59.00 | 18.00 | 0.10 | 53.00 | 30.00 | 20.30 | 42.90 | 21.00 |
| | | 00:00 | 27.12 | 57.70 | 18.00 | 0.10 | 53.00 | 30.00 | 20.00 | 42.00 | 21.00 |
| | | 01:00 | 27.12 | 56.90 | 18.00 | 0.10 | 53.00 | 30.00 | 19.70 | 41.10 | 21.00 |
| | | 02:00 | 27.12 | 56.00 | 18.00 | 0.10 | 53.00 | 30.00 | 19.40 | 40.20 | 21.00 |
| | | 03:00 | 27.12 | 55.00 | 18.00 | 0.10 | 53.00 | 30.00 | 19.10 | 39.30 | 21.00 |
| | | 04:00 | 27.12 | 54.00 | 18.00 | 0.10 | 53.00 | 30.00 | 18.80 | 38.40 | 21.00 |
| | | 05:00 | 27.12 | 53.00 | 18.00 | 0.10 | 53.00 | 30.00 | 18.50 | 37.50 | 21.00 |
| | | 06:00 | 27.12 | 52.00 | 18.00 | 0.10 | 53.00 | 30.00 | 18.20 | 36.60 | 21.00 |
| | | 07:00 | 27.12 | 51.00 | 18.00 | 0.10 | 53.00 | 30.00 | 17.90 | 35.70 | 21.00 |
| | | 08:00 | 27.12 | 50.00 | 18.00 | 0.10 | 53.00 | 30.00 | 17.60 | 34.80 | 21.00 |
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| | | 10:00 | 27.12 | 48.00 | 18.00 | 0.10 | 53.00 | 30.00 | 17.00 | 33.00 | 21.00 |
| | | 11:00 | 27.12 | 47.00 | 18.00 | 0.10 | 53.00 | 30.00 | 16.70 | 32.10 | 21.00 |
| | | 12:00 | 27.12 | 46.00 | 18.00 | 0.10 | 53.00 | 30.00 | 16.40 | 31.20 | 21.00 |
| | | 13:00 | 27.12 | 45.00 | 18.00 | 0.10 | 53.00 | 30.00 | 16.10 | 30.30 | 21.00 |
| | | 14:00 | 27.12 | 44.00 | 18.00 | 0.10 | 53.00 | 30.00 | 15.80 | 29.40 | 21.00 |
| | | 15:00 | 27.12 | 43.00 | 18.00 | 0.10 | 53.00 | 30.00 | 15.50 | 28.50 | 21.00 |
| | | 16:00 | 27.12 | 42.00 | 18.00 | 0.10 | 53.00 | 30.00 | 15.20 | 27.60 | 21.00 |
| | | 17:00 | 27.12 | 41.00 | 18.00 | 0.10 | 53.00 | 30.00 | 14.90 | 26.70 | 21.00 |
| | | 18:00 | 27.12 | 40.00 | 18.00 | 0.10 | 53.00 | 30.00 | 14.60 | 25.80 | 21.00 |
| | | 19:00 | 27.12 | 39.00 | 18.00 | 0.10 | 53.00 | 30.00 | 14.30 | 24.90 | 21.00 |
| | | 20:00 | 27.12 | 38.00 | 18.00 | 0.10 | 53.00 | 30.00 | 14.00 | 24.00 | 21.00 |
| | | 21:00 | 27.12 | 37.00 | 18.00 | 0.10 | 53.00 | 30.00 | 13.70 | 23.10 | 21.00 |
| | | 22:00 | 27.12 | 36.00 | 18.00 | 0.10 | 53.00 | 30.00 | 13.40 | 22.20 | 21.00 |
| | | 23:00 | 27.12 | 35.00 | 18.00 | 0.10 | 53.00 | 30.00 | 13.10 | 21.30 | 21.00 |
| | | 00:00 | 27.12 | 34.00 | 18.00 | 0.10 | 53.00 | 30.00 | 12.80 | 20.40 | 21.00 |
| | | 01:00 | 27.12 | 33.00 | 18.00 | 0.10 | 53.00 | 30.00 | 12.50 | 19.50 | 21.00 |
| | | 02:00 | 27.12 | 32.00 | 18.00 | 0.10 | 53.00 | 30.00 | 12.20 | 18.60 | 21.00 |
| | | 03:00 | 27.12 | 31.00 | 18.00 | 0.10 | 53.00 | 30.00 | 11.90 | 17.70 | 21.00 |
| | | 04:00 | 27.12 | 30.00 | 18.00 | 0.10 | 53.00 | 30.00 | 11.60 | 16.80 | 21.00 |
| | | 05:00 | 27.12 | 29.00 | 18.00 | 0.10 | 53.00 | 30.00 | 11.30 | 15.90 | 21.00 |
| | | 06:00 | 27.12 | 28.00 | 18.00 | 0.10 | 53.00 | 30.00 | 11.00 | 15.00 | 21.00 |
| | | 07:00 | 27.12 | 27.00 | 18.00 | 0.10 | 53.00 | 30.00 | 10.70 | 14.10 | 21.00 |
| | | 08:00 | 27.12 | 26.00 | 18.00 | 0.10 | 53.00 | 30.00 | 10.40 | 13.20 | 21.00 |
| | | 09:00 | 27.12 | 25.00 | 18.00 | 0.10 | 53.00 | 30.00 | 10.10 | 12.30 | 21.00 |
| | | 10:00 | 27.12 | 24.00 | 18.00 | 0.10 | 53.00 | 30.00 | 9.80 | 11.40 | 21.00 |
| | | 11:00 | 27.12 | 23.00 | 18.00 | 0.10 | 53.00 | 30.00 | 9.50 | 10.50 | 21.00 |
| | | 12:00 | 27.12 | 22.00 | 18.00 | 0.10 | 53.00 | 30.00 | 9.20 | 9.60 | 21.00 |
| | | 13:00 | 27.12 | 21.00 | 18.00 | 0.10 | 53.00 | 30.00 | 8.90 | 8.70 | 21.00 |
| | | 14:00 | 27.12 | 20.00 | 18.00 | 0.10 | 53.00 | 30.00 | 8.60 | 7.80 | 21.00 |
| | | 15:00 | 27.12 | 19.00 | 18.00 | 0.10 | 53.00 | 30.00 | 8.30 | 6.90 | 21.00 |
| | | 16:00 | 27.12 | 18.00 | 18.00 | 0.10 | 53.00 | 30.00 | 8.00 | 6.00 | 21.00 |
| | | 17:00 | 27.12 | 17.00 | 18.00 | 0.10 | 53.00 | 30.00 | 7.70 | 5.10 | 21.00 |

So our challenge is to conceive a methodology to assist decision making in architectural design for pre-existing adapted museums buildings.

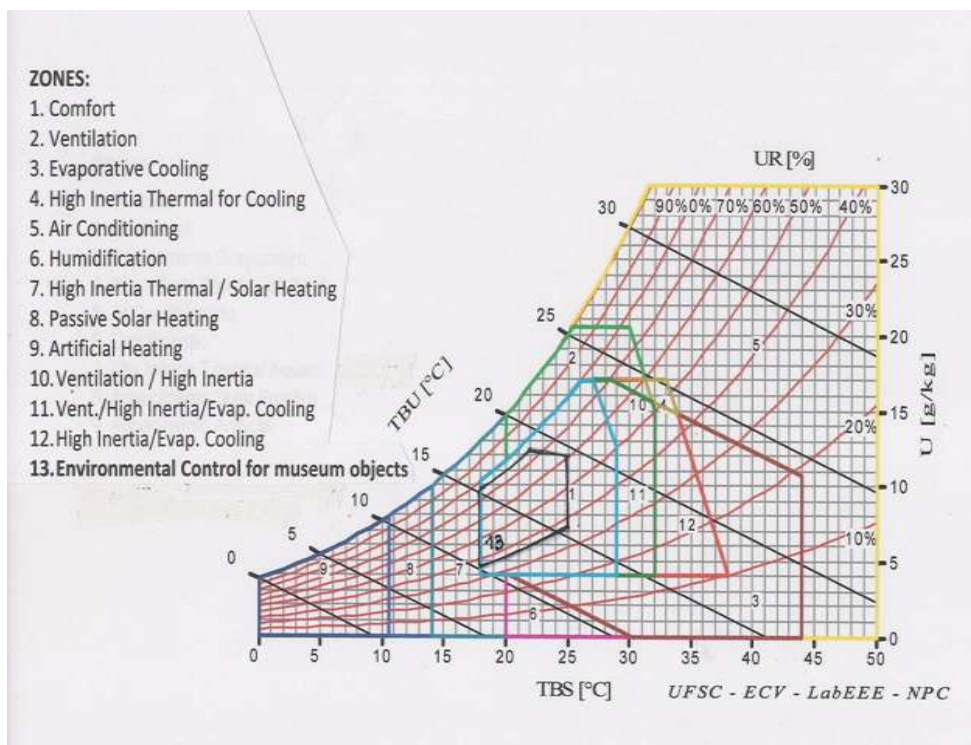


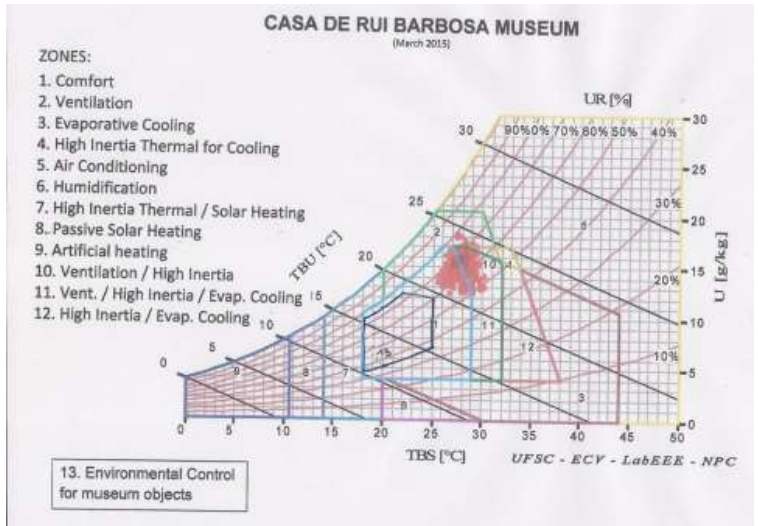
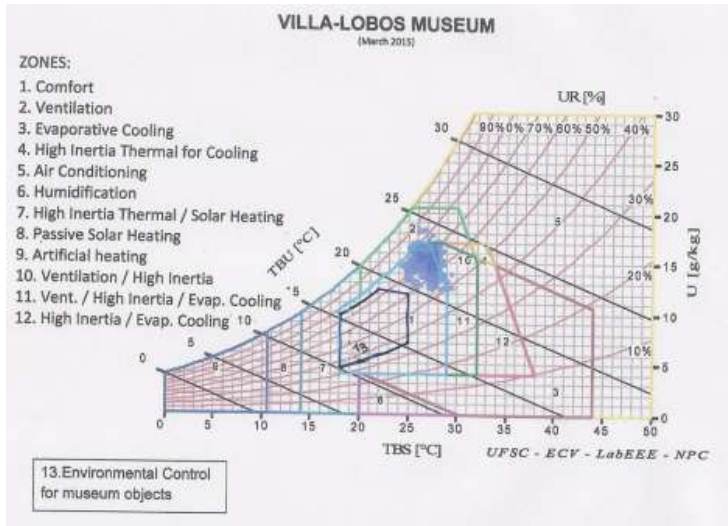
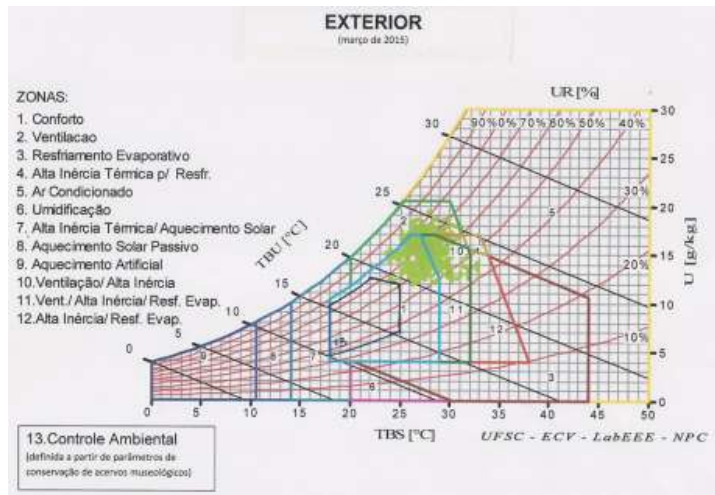
In this Givoni diagram it is depicted the zone for human environmental comfort and identified other adjacent areas, with the strategies that should be adopted for achieving environmental comfort.

In Climate Conference - Climate for Collections - Lukasz Bratasz has systematized data on temperature and relative humidity. In his article are gathered the main institutions dedicated to the subject, that identified limits for conservation:

We have included in the Bioclimatic Diagram of Givoni these parameters identifying another zone

- 1978 - Garry Thomson __ Class 1: temperature between 19°C and 24°C and relative humidity of 50% to 55% (+/- 5 ° C) and class 2 fairly constant temperature and relative humidity of 40% to 70%;
- 1979 - Canadian Conservation Institute __ T = 20 ° C to 25 ° C and RH = 47% to 53% (long-term average), 38% to 55% (seasonal cycle), +/- 2% (short-term fluctuations);
- 1994 - National Trust __ T = 5 ° C to 22 ° C and RH = 58% (long-term average), 50% to 65% (alarm level 1), 40% to 75% (alarm level 2);
- 1999 - ASHRAE __ T = 15 ° C to 25 ° C and RH = 50% +/- 10% and below 75%;
- 2006 - National Trust __ T = 5 ° C to 22 ° C and RH = 50% to 65%;
- 2007 - Smithsonian Institution __ T = 21 ° C and RH = 45% +/- 8%
- 2009 - National Museum Directors Conference UK __ T = 16°C to 25°C and 40% RH = 60%;
- 2010 - European Standard IN 15757 2010 __ T = not specified and UR = annual historical averages and the seasons +/- 10%;(Bratasz, 2013)





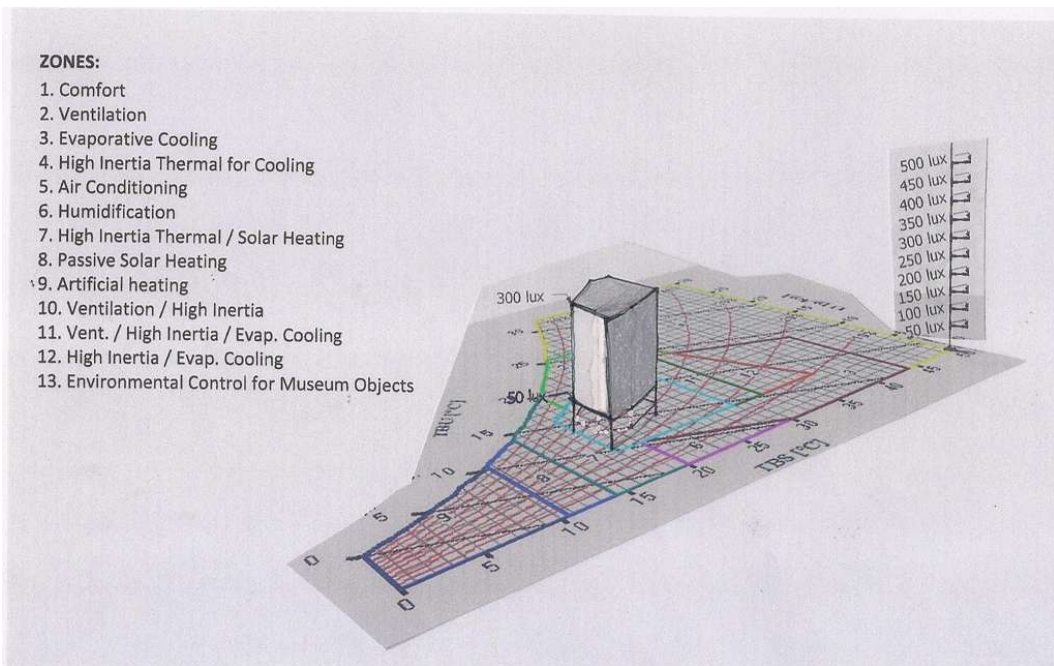
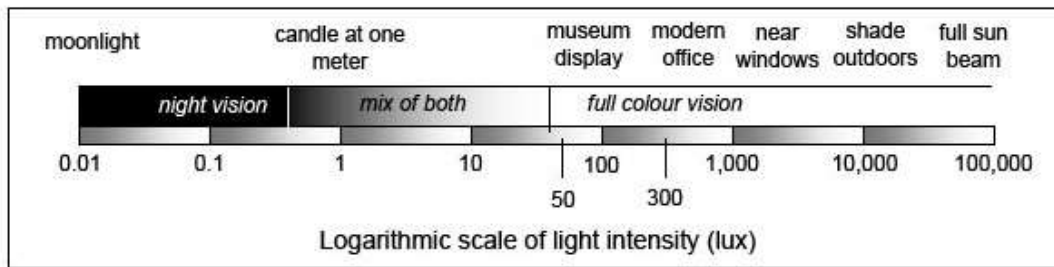
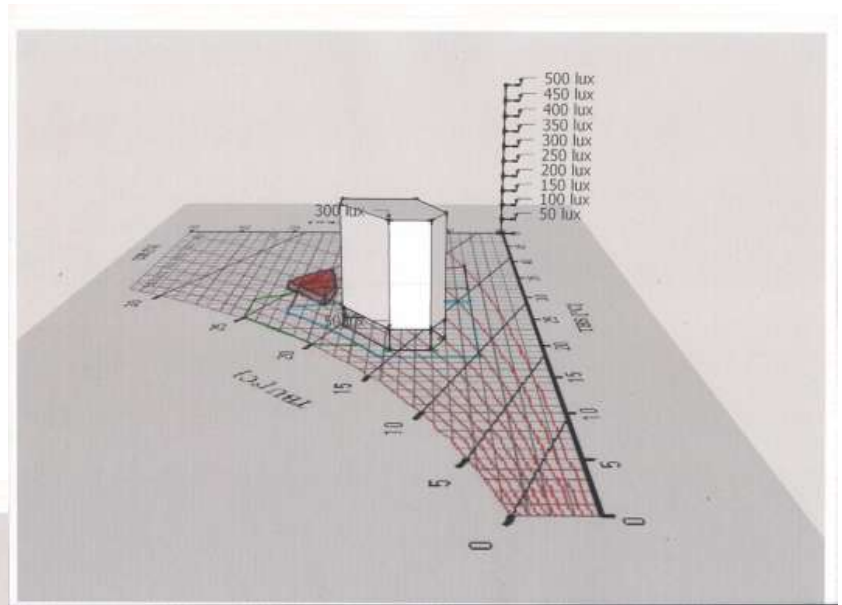
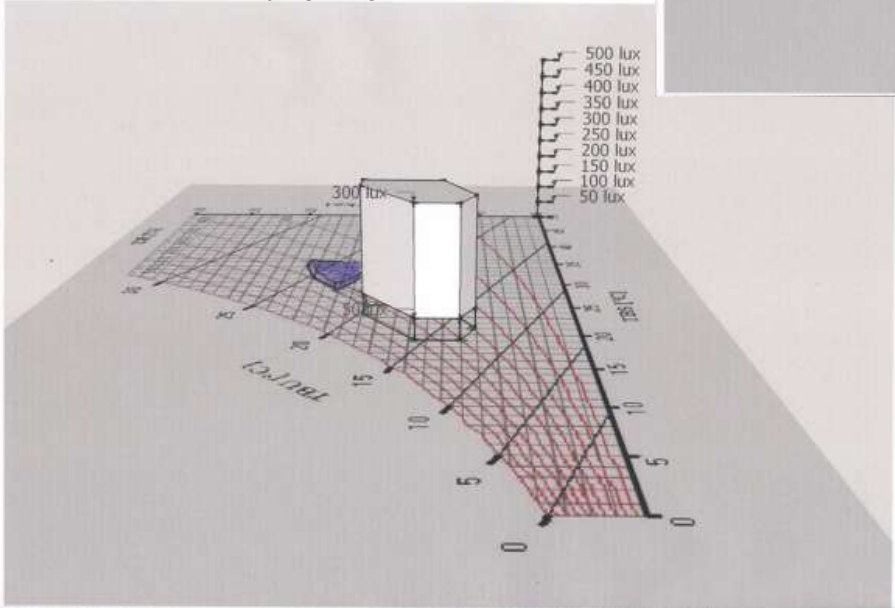


Diagram 3D - Bioclimatic strategies for architecture, including conservation zone for objects

Villa-Lobos Museum
temperature/humidity/lighting - March 2015



House of Rui Barbosa Museum
temperature/humidity/lighting - March 2015

Table 2
Suggested values for the optimal conservation of works of art for steady-state indoor climate conditions (UNI 10829 standard and Minister Decree May 2001)

| Work of art materials | t_0 (°C) | Δt_{max} (°C) | u_0 (%) | Δu_{max} (%) |
|--|-------------------|-----------------------|------------------------|----------------------|
| Organic materials/object | | | | |
| Paper, paper (waxed), paper artwork, tissue-paper, wallpaper, stamp collection, manuscripts, papyri, paintings, cellulose materials | 18–22 15–24 | 1.5 | 40–55 50–60 | 6 |
| Fabric, veils, cloques, carpets, fabric tapestry, arms, silk, costumes, dresses, religious vestments, natural fibre materials, steel, jute | 19–24 | 1.5 | 30–50 40–60 | 6 |
| Wax, anatomical waxes | <18 | N.S. | N.S. | N.S. |
| Herbaria and botanical collections | 21–23 | 1.5 | 45–55 40–60 | 2 |
| Entomological collections | 19–24 | 1.5 | 40–60 | 6 |
| Animals and anatomical organs preserved in formalin | 15–25 | – | N.S. | N.S. |
| Animals, dried anatomical organs, mummies | 21–23 | 1.5 | 20–35 40–60 | – |
| Furs, fashions, stuffed animals and birds | 19–24 | 1.5 | 30–50 45–60 | 5 |
| Water-colours, drawings, pastels | 19–24 | 1.5 | 45–60 50–60 | 2 |
| Ethnographic collections, masks, leather, leather clothes | 19–24 | 1.5 | 45–60 50–60 | 6 |
| Painting on canvas, oil painting on cloth and canvas, tempera, gouaches | 19–24 | 1.5 | 40–55 35–50 | 6 |
| Documents, file material | 13–18 | – | 50–60 | – |
| Books of great value; leather-bound books, leather bindings, parchment, miniatures | 19–24 | 1.5 | 45–55 50–60 | 6 |
| Lacquer, inlaid, decorated or lacquer furniture | 19–24 | 1.5 | 50–60 | 2 |
| Polychromatic wood carvings, painted wood, paintings on wood, icons, wood pendulum-clocks, wood musical instruments | 19–24 | 1.5 | 50–60 45–65 | 2 |
| Unpainted wood carvings, wickerwork, wood or bark panels | 19–24 | 1.5 | 45–60 40–65 | 2 |
| Inorganic materials/object | | | | |
| Pottery, ceramics, stoneware, terracotta, tiles and deintercalated tiles from excavation | N.S. | – | N.S. | 10 |
| Stones, rocks, ore and stable (poison) meteorites | 19–24 | – | 20–60 40–60 | 6 |
| Stone mosaics, stones, rocks, on, meteorites (not porous), fossils and stone collections | 15–25 | – | 20–60 45–60 | 10 |
| Metals, smoothed metals, metal alloys, silver, armour, weapons, bronzes, coins, copper objects, tin, iron, steel, lead, pewter | N.S. | – | <50 <35 | – |
| Metals with active corrosion sites | N.S. | – | <40 | – |
| Gold | N.S. | – | N.S. | – |
| Gypsum and plaster | 21–23 | 1.5 | 45–55 | 2 |
| Unstable, alkaline and sensitive glass, primitive glass mosaics | 20–24 | 1.5 | 40–65 | – |
| Various object | | | | |
| Murals, frescoes, simple (stretched) | 10–24 | – | 55–65 45–60 | – |
| Dry murals (detached) | 10–24 | – | 50–65 45–60 | – |
| Ivories, horns, malacological collections, eggs, nests, corals | 19–24 | 1.5 | 40–60 45–65 | 6 |
| Photographic records | 10–21 | – | 40–55 40–60 | 2 |
| Man-made fibres | 19–24 | – | 40–60 | – |
| Film, colour photograph | 0–15 | – | 30–45 | – |
| Film, black and white photograph | –15 to –5 5–15 | – | 30–50 40–60 | – |
| Organic material objects coming from damp excavation areas (before treatment) | 19–24 | – | Saturated air 50–65 | – |
| Plastics | 19–24 | – | 30–50 | – |

N.S. = not significant.

UNI 10829 - suggested values for the optimal conservation of works of arts for steady-state indoor climate conditions

Mean monthly value of the air temperature - q_0

Daily range of air temperature - Dq_{max}

Mean monthly value of the relative humidity of indoor air - u_0

Daily range of relative humidity of air - $Dumax$

wood musical instruments

q_0 (°C) 19–24 °C Dq_{max} (°C) 1.5°C

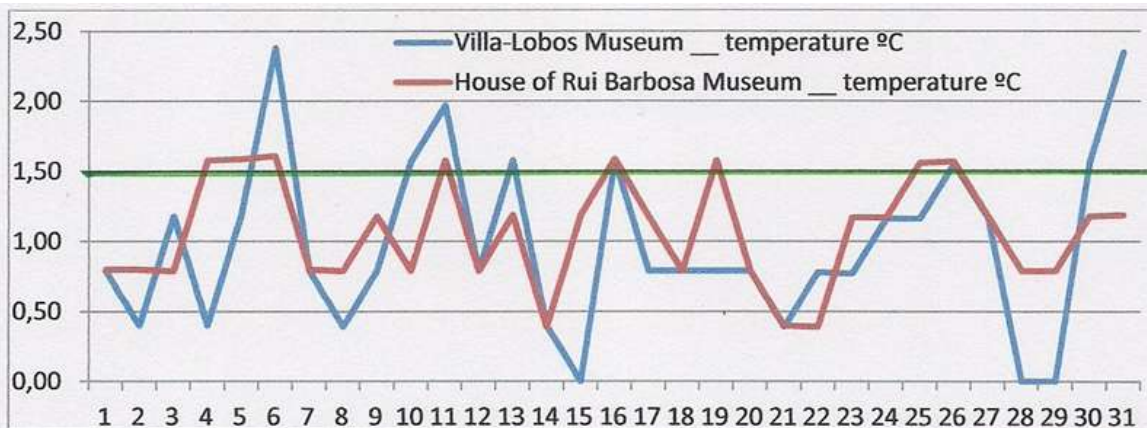
u_0 (%) 45–65 $Dumax$ (%) 2%

Books of great value, leather-bound books, leather bindings, parchment, miniatures

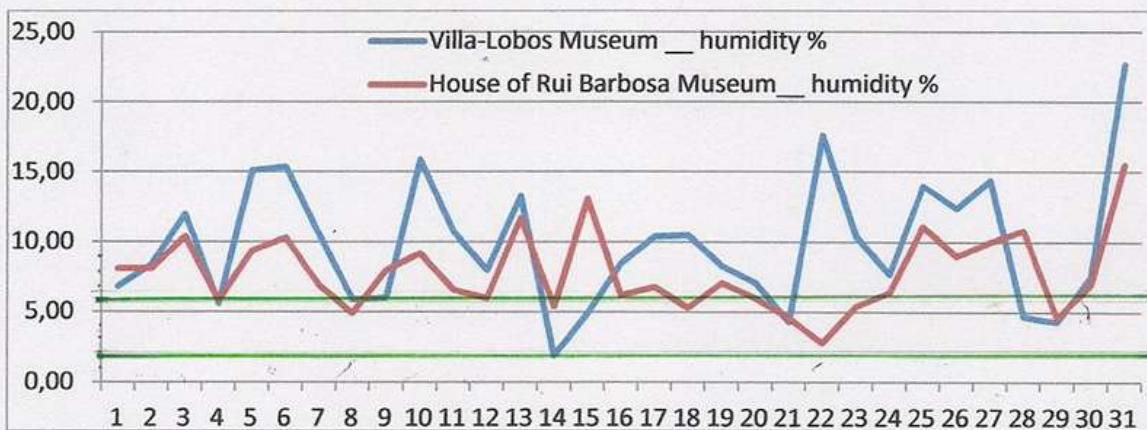
q_0 (°C) 19–24°C Dq_{max} (°C) 1.5°C

u_0 (%) 45–55 $Dumax$ (%) 6%

MARCH 2015 - daily variations

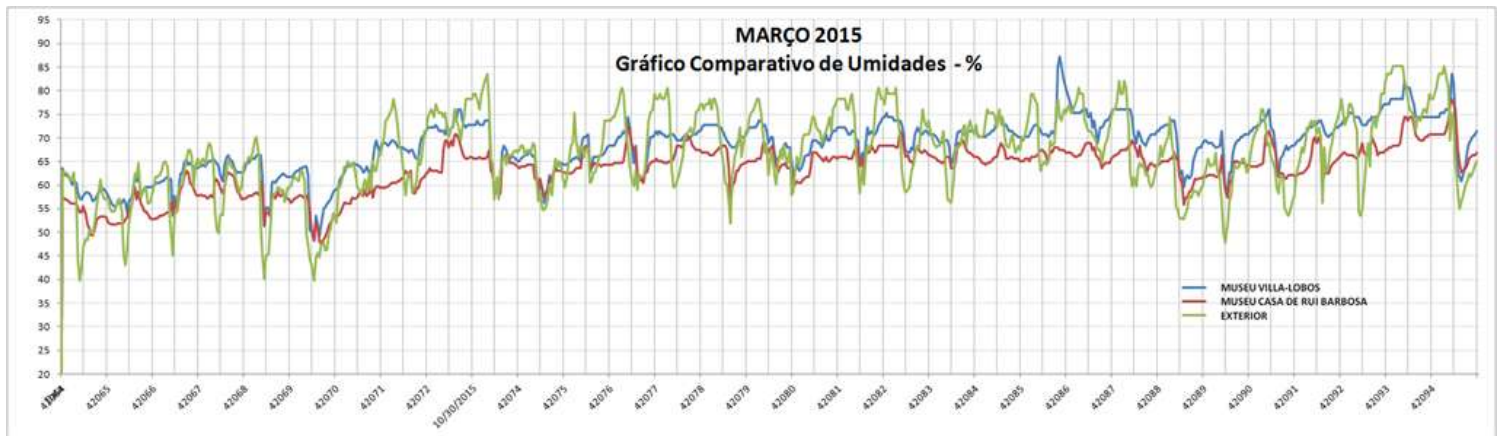


UNJ
10829

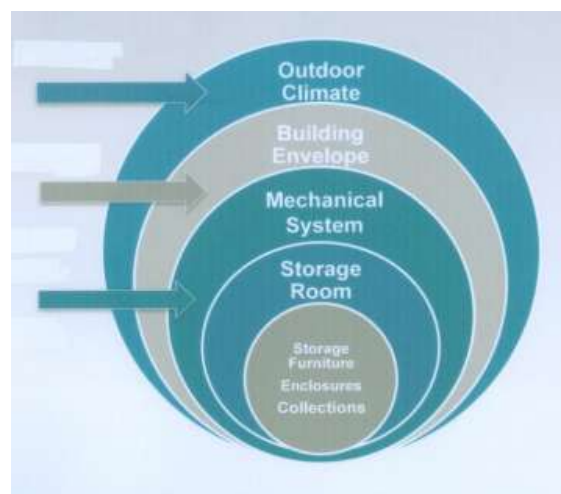


BOOK OF GREAT
VALUE
6%
2%
WOOD MUS.
INSTRUMENT

MARCH 2015 - comparison of moisture in the 3 points measured



Understanding the preservation of museum collections, with reference to the performance of protective layers, helps to see the contribution that the museum architecture can offer to this field, as well as the potential and limits that every old building has in creating a microclimate adequate to preserve the collections at lower cost and power consumption.



From the physical point of view, the Building Envelop performs the separation between the internal and the external environments, offers resistance to air, water, heat transfer, light, noise, but it is also the most visible part of the building, showing its style of expression and architectural form, with great symbolic image and time identification in the cities, especially in historical buildings.

Acting in Building Envelop requires the integration of methodologies such as the preservation of the architecture with bioclimatic architecture.

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THANK YOU

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OIKOS architecture and environmental engineering