THIRD PART

Chapter 6

Analyses and validation of operative tools

"The finest workers in stone are not copper or steel tools,
but the gentle touches of air and water working at their leisure
with a liberal allowance of time".
Henry David Thoreau

6.0 Chapter abstract

This chapter aims at analyzing all the operative tools involved in this research project in order to give a clear picture about the current possibilities offered by technologies for the conservation of buildings and sites. Since the 190s, the technological support to the field of heritage preservation and enhancement has improved the knowledge and analyses on historic buildings. Through the work of several research centres, mainly located in US and Europe, operational methodologies involving 3D geometric models and virtual representations of monumental architecture have been develop.

These tools can effectively support a wide range interdisciplinary analyses in sectors related to the conservation and restoration of archaeological sites and architectural structures. These technologies are particular efficient when applied to 3D surveying, solid prototyping of architectural features and artefacts, multispectral surveying, the study of historic materials and the technical-structural problems of historic structures. Digital tools and computer aided drawings could be integrated in surveys in support of projects for the restoration and conservation of the architectural and archaeological heritage in relation to the environment and geographical area.

During the last two decades, private companies in cooperation with universities and research institutes have been testing instruments and techniques for acquiring 3D data on various scales and degrees of accuracy to develop experimental procedures and methods to control dimensional data and carry out structural, environmental and other assessments and verifications.

6.1 Application of integrated methodology for representation and survey

An integrated methodology for the survey and representation of the modernist architecture can be very effective if properly managed and coordinated. Each technology helps to improve the knowledge towards a particular aspect of the architectural object but sometimes it is not enough to understand all the peculiar problems. The interaction of different technologies allows to then exploit the advantages of each, and even diminish the effect of the specific weaknesses.

The works that can be carried out by an integrated methodology are also much more informative and can be shared also by experts in each field related to preservation of cultural heritage. Among these tools this research project had been taking advantage of 3D laser scanner survey, 3D modelling and prototyping, surface diagnostic analyses and 3D database.

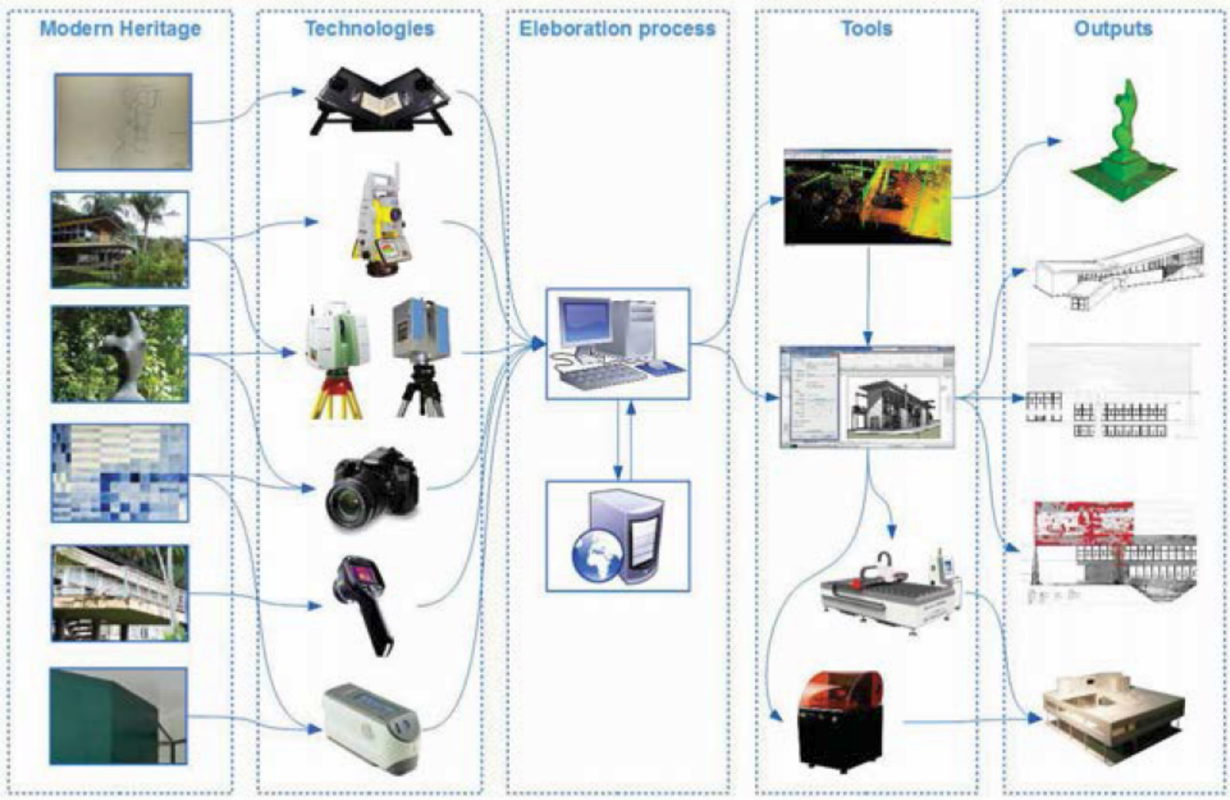


Figure 6.1: 3D survey and representation methodological scheme.

6.1.1 3D Advanced survey

The methodological path that connects the direct acquisition of data in 3D to the final user of it (researchers, professionals, students, etc.) is always aimed at avoiding (or at least limiting) the loss of information due to the need of a two-dimensional synthesis or 3D volumetric reconstruction of the architectural object.

The opportunities offered by digital morphometric survey are influencing the development of investigation processes, monitoring procedures and restoration works in the strategies and plans for the preservation, maintenance and rehabilitation of historical buildings and structures. Accuracy and precision of the 3D Laser Scanner survey demonstrated to be a crucial support for the quality of the design activities in the interventions on historical compounds.

The laser scanner survey methods have been consolidated in recent years, although there are still by some scholars some misconceptions, such as that of considering the registration of the point cloud the end point (end result) of the discovery process.

Nowadays some practices are trying to evaluate if it could be possible to design directly into the point loud, without need of exportation of data from data capture software to others. In this case the assessment of the technical solutions could be based on reliable data, particularly in those areas where a traditional survey is very difficult (or sometimes impossible) because of the inaccessibility of some spaces.

For instance the "MUDI project", the restoration works for the *Museo degli Innocenti* in Florence – benefitted by this opportunity: the project combined the design process with the high density information of morphometric models[1.]

Beside this advanced practices nowadays is still important to clarify that for the majority of the users the numerical model is the initial phase of the laser survey while the final stage is the geometric model, or mathematical model, from which drawings can be derived and represent the result of the whole process.

Talking about point cloud data it is worth mentioning the results achieved in photo modelling field in order to generate 3D data base. It consists in the restitution from photographs of 3D dense point cloud and/or textured mesh models, using the principles of projective geometry.

Even if it is not as accurate a traditional lidar modelling they can fill the gap between a very time-consuming activity and the traditional use of data in architectural office during preliminary phases of a project. Probably photo modelling will be one of the next frontiers of the architectural, archaeological and urban, survey[2].

[1] For more info on the MUDI project: R. DI GIULIO et al., *Restoration works at the Museo degli Innocenti in Florence: designing into the point cloud*, pag. 117-124 Volume 1, in "Rehab 2014 – Proceedings of the International Conference on Preservation, Maintenance and Rehabilitation of Historic Buildings and Structures", Tomar, Portugal 19-21 March 2014, Editors: Rogério Amoêda, Sérgio Lira & Cristina Pinheiro, Publisher: Green Lines Institute, 2014 (ISBN: 978-989-8734-01-3, e-ISBN: 978-989-8734-02-0)

[2] See: Docci, M., Filippa, M., & Chiavoni, E. (2011). *Metodologie integrate per il rilievo, il disegno, la modellazione dell'architettura e della città*. Rome: Gangemi.

6.1.2 3D modelling and prototyping

There are two important aspects connected to the 3D modelling field. On one hand, the potential of a 3D model of the object: if the geometrical properties and materials are inserted inside a simple calculation scheme, but consistent with the objectives to be achieved, and managed by specific software, it becomes possible to produce, for example, realistic simulations of the philological reconstruction of it. In this way the architects, archaeologist can develop studies for a better understanding of the cultural heritage as well as more efficient schedule for maintenance operations: the 3D model in this way can allows the virtual verification of procedures and operations related to the time factor.

On the other hand there is the chance, starting from the three-dimensional digital model, to create physical models in different scales with rapid prototyping technologies available today.

It should be emphasized that the use of physical models in the field of preservation of monuments can allow on one side the modelling of complex shapes and the other the direct simulation of the restoration work on the scale model, by helping to assess, for example, before evidence on the monument, removing additions and, in some cases, the reintegration of the gaps.

The modern rapid prototyping technologies help to fill, at least in part, that gap which in some cases is felt between the digital data and the material reality. There are a number of other application areas where rapid prototyping has been used to good effect and one of these is architectural modelling. However, such application areas often have different requirements from what is offered by the current technology [3]. The applied methods can also help in showing the value of cultural heritage, and, not least, in allowing access both to scholars specialists (who can perform real simulations on the digital model) and to a wider audience of fans, thanks to multimedia resources. In this area of interest interesting project have been develop to reproduce touchable copy of masterpiece sculpture for visually impaired people.

6.1.3 Surface diagnostic analyses

The digital acquisition of surface specifications, including chromatic descriptions, material and morphological aspects, macroscopic alterations linked to degradation aims at identify connections between structural specifications and states of alteration and degradation provided an useful picture of the state of conservation of modern cultural heritage; this kind of investigation is usually developed through the processing of reflection data acquired in the 3D scanner laser ray reading (limited to a precise band of the spectrum).

The activity is directed to the creation of integrated systems of accurate dimensional data and surface quality (diagnostic and conservative analysis, advanced colorimetric analysis, etc.).

[3] Gibson, I., Kvan, t., Wai Ming, L. (2002). *Rapid prototyping for architectural models*, in Rapid Prototyping Journal, Vol. 8 Iss: 2, pp.91–95.

The reflectance data are acquired by the laser scanner as well as the metric data. Reflectance is the intensity of the laser beam at the moment of the “impact” with the object to be surveyed and it allows the visual recognition of the different materials, of the surface specifications and state of conservation. This kind of investigation are performed by processing the reflection data and was followed by a more detailed analysis of the colorimetric data based on spectrophotometer techniques. These techniques are integrated with microscopic direct observations by using both indirect and side light in order to identify and to understand the significant features and surface specifications of the surfaces, the morphological aspects and macroscopic alterations.

Another activity that is part of this integrated methodology can be carried out by non-invasive diagnostic imaging via infrared thermographic survey. In construction, architecture and monitoring of architectural heritage, there has been a recent and progressive interest in this form of investigation as it can get real-time images that, in fact, can be acquired and evaluated in the presence of users, providing instant information also decisive and discriminating about the state of the structure. Thermography is understood as a graphical representation of the "thermal state" of a body, or as a representation of the "map" of the surface temperatures of the body itself. This is possible because all bodies with a temperature above absolute zero (-273 ° C), emit and absorb infrared radiation up to achieve a proper thermal equilibrium that depends on internal situations of the material, external of the surrounding environment or from both factors. Since such radiation are not "visible" to human eye, instruments used for the thermographic detection allow to associate, to each temperature value detected, a color, chosen from a specific chromatic scale corresponding to the range of temperatures set manually by the user.

Thermographic survey technique provides a true "thermal image" of the building feature, without any physical contact and without affecting in any way neither the surface temperature nor the morphology of the object itself.

6.1.4 3D database

An integrated three-dimensional database made up of BIM models, specifically tailored to the work of the historian / architecture, the researcher or the restorer working in the field, but also to consult the interested scholar could greatly improve the knowledge on modern buildings not only in Brazil and India but also in other countries. It can consist of a summary representation of the original material and the processed one.

In this way, the operator could have the possibility of consulting the digital archive and working independently taking advantage of the available data and thus possibly obtaining results that the scientific community might not even have considered. Moreover, the decision to build an on-line database accessible via web browser gives the chance to immediately share the results of research with other users. The methods described above could constitute an effective working tool aimed at the knowledge and appreciation of the modernism heritage, and a cultural tool, since it can successfully bring these works ready to be shared on the internet.

6.2 Technical information about equipment and tools of analysis

In an integrated advanced methodology, digital tools and equipment are crucial points in order to achieve the main goal of the research. In this section the applied software and the utilized equipment are described in order to highlight their main features.

Both software and equipment were used free of charge thanks to the cooperation with private companies that kindly offered their support to this research, such as Autodesk, Leica Geosystem, Z+F and Geomax. The cooperation with 3D laser scanner manufacturers has been particularly important also as for the test phase of the application of these machines to the modern cultural heritage field with all the related problems (see for example high presence of glass due to very often big window cases or body water located around buildings) with the main goals to set a new benchmark in this field for these technologies.

6.2.1 Software applied to this research

Autodesk Revit 2017

The Autodesk Revit 2017 work environment allows users to manipulate whole buildings or assemblies (in the project environment) or individual 3D shapes (in the family editor environment). Modeling tools can be used with pre-made solid objects or imported geometric models. However, Revit is not a NURBS modeller and also lacks the ability to manipulate an object's individual polygons except on some specific object types such as roofs, slabs and terrain or in the massing environment. An experienced user can create realistic and accurate families ranging from furniture to lighting fixtures, as well as import existing models from other programs. Revit families can be created as parametric models with dimensions and properties. This lets users modify a given component by changing predefined parameters such as height, width or number in the case of an array. In this way a family defines a geometry which is controlled by parameters, each combination of parameters can be saved as a type, and each occurrence (instance in Revit) of a type can also contain further variations. For example, a swing door may be a Family. It may have types describing different sizes, and the actual building model will have instances of those types placed in walls where instance-based parameters could specify the door hardware uniquely for each occurrence of the door. Although Revit software comes with a range of families out of the box (OOTB), they are limited, so users can find a need to build their own families or buy them from online stores[4].

Cinema4D

[4] For more info on Revit see: http://www.autodesk.it/products/revit-family/overview

CINEMA 4D is a 3D modeling, animation and rendering application developed by MAXON Computer GmbH in Germany. It is capable of procedural and polygonal modeling, animating, lighting, texturing, rendering, and common features found in 3D modelling applications.
Four variants are currently available from MAXON: a core CINEMA 4D 'Prime' application, a 'Broadcast' version with additional motion-graphics features, 'Visualize' which adds functions for architectural design and 'Studio', which includes all modules.
2014 saw the release of a 5th variant, "Lite", which comes packaged with Adobe After Effects Creative Cloud 2014, and acts as an introductory version, with many features withheld. This is part of a new partnership between the two companies, where a new, MAXON produced plug-in called CINEWARE, allows any variant to create a seamless workflow with After Effects[5].

Leica Cyclone 9.1

Leica Geosystems HDS Cyclone is a software which provides point cloud users with a wide set of work process options for 3D laser scanning projects.
Cyclone lets users take advantage of traverse, back-sight, and resection capabilities of the new laser scanners laser scanner for more cost-effective as-built and topographic surveys and lets users create plant as-built models more efficiently from laser scans.
Cyclone's Object Database Client/Server software architecture provides a high performance environment for laser scanning projects. Cyclone software allows to manage data efficiently in databases and it can import the native point cloud formats from many manufacturers such as Faro, Riegl, Optech, and Z&F[6].

6.2.2 Equipment employed in this research project

Leica Scan Station C10

ScanStation C10 allows maximum flexibility in dealing with site logistics. It does full dome scans up to 10x faster – now, less than 2 minutes for a typical room. It also conducts general 360º and focused areas scans faster, can be set up & moved faster, lets users locate targets, register & geo-reference faster and lets users check scan results faster. Scan Station C10 is easy to learn, with a total station-like interface and intuitive, onboard graphic colour touchscreen display.
It is also incrementally upgradeable over time, uses standard total station batteries, and features fewer accessories – all of this contributes to a reduced cost of ownership.

[5] For more info on Cinema 4D see: https://www.maxon.net/it/prodotti/cinema-4d/cinema-4d/

[6] For more info on Cyclone 9.1 see: http://leica-geosystems.com/products/laser-scanners/software/leica-cyclone

Compatibility with standard surveying equipment as Leica GPS SmartAntenna or prism holder, or use without handle for unobstructed overhead scans.

A built-in laser plummet and tribrach mount provide added compatibility with standard field procedures and accessories.

Leica Scan Station C10 laser scanner[7]	
Max Range	300m @ 90% reflectivity
Min Range	0.1m
Horizontal field of view	360°
Vertical field of view	270°
Scan rate	50.000 points/sec
Resolution	
Distance accuracy	4mm @ 50m
Internal camera resolution	-
Weight with battery	13.4 kg

Table 6.1: Leica Scan Station C10 main features.

Leica Scan Station P40

The ScanStation P40 offers highest versatility including long range capabilities. It is a suitable solution for any tasks in 3D laser scanning.

With its optimal mix of speed, range and accuracy paired with unmatched robustness it is the all-in-one solution for the most comprehensive variety of applications.

The Leica ScanStations deliver highest quality 3D data and HDR imaging at fast scan rate of 1 million points per second at ranges of up to 270 m. A top level market solution with low range noise and survey-

[7] Data source: http://hds.leica-geosystems.com

grade dual-axis compensation form the foundation for highly detailed 3D colour point clouds mapped in realistic clarity.

Leica Scan Station P40 laser scanner[8]	
Max Range	270m @ 34% reflectivity
Min Range	0.4m
Horizontal field of view	360°
Vertical field of view	290°
Scan rate	1.000.000 points/sec
Distance accuracy	4mm @ 50m
Internal camera resolution	4 megapixels per each 17° × 17° colour image; 700 megapixels for panoramic image
Weight with battery	12.65 kg

Table 6.2: Leica Scan Station P40 main features.

Geomax sps zoom 300 laser scanner

ZOOM 300 could be a cheaper solution for 3D survey requirements, a possible alternative to the top and more expansive Laser scanner built by Leica and Z+F companies. This scanneroffer a compact design and it is very lightweight and portable. It can be used in all working environments, especially topographic surveys and 3D survey for infrastructure as its sealed casing protects the internal components, providing an IP65 dust and waterproof rating.

ZOOM 300 is simple to use and ready to scan at the press of a button. The scanner can be controlled and operated directly from all mobile devices with a WLAN connection. A menu driven interface makes selection straightforward.

[8] Data source: http://hds.leica-geosystems.com

Geomax sps zoom 300 laser scanner[9]	
Max Range	300m @ 100% reflectivity
Min Range	2.5m
Horizontal field of view	360°
Vertical field of view	90° (-25° +65°)
Scan rate	40.000 points/sec
Resolution	37mm x 37mm @ 100m
Distance accuracy	6mm @ 50m<10mm @ 100m
Internal camera resolution	-
Weight with battery	7 kg

Table 6.1: Geomax sps zoom 300 main features.

[9] Data source: http://www.geomax-positioning.com/

FOURTH PART

Chapter 7

Identification of case studies in Brazil and India

"The dynamic transfer of ideas and the importation of European culture,
such as classical modernism, into emerging countries such as Brazil or India,
is generally a challenging phenomenon"
Steffen Hellman

7.0 Chapter abstract

The identification of more than 250 buildings both Brazilians and Indians of the modernist period cannot be completely exhaustive in describing these two complicated phenomena as they are sometimes difficult to be interpreted. Furthermore the scarce sources available, part f the which are unfortunately disappearing in old archives, are sometimes kept alive only thanks to the effort of the descendants of some architects willing to preserve the memory of the works designed by their relatives.

The result of what we might call an initial selection (because surely many modernist buildings in the two countries are not included in this collection) is the result of archive and on field research personally performed in the two vast territories. The monographies consulted allowed to deepen the knowledge and to describe the most important modernist buildings in Brazil and India. On this great collection of information was then applied a first selection filter of eighty buildings on which the survey of the original project has been carried out through interpretative sketches. A further analysis filter has seen the application of BIM methodologies to get to the creation of digital models from which drawings and principles were extracted.

A final filter finally allowed to identify on which case studies to apply an integrated three-dimensional survey methodology. On these examples, working in collaboration with local partner institutions, the research have been able to also offer capacity-building programmes and technology transfer seminars that are still under development but with great promise for the near future of modern architecture in Asia and South America.

7.1 Case studies: preliminary information

The literature review carried out during this research has led to the identification of more than 250 buildings both Brazilians and Indians of the modernist period mainly built in reinforced concrete. This selection cannot be completely exhaustive in describing these two complicated phenomena: they are sometimes difficult to be interpreted and often there are scarce sources available, part f the which are unfortunately disappearing in old archives, are sometimes kept alive only thanks to the effort of the descendants of some architects willing to keep alive the memory of the works designed by their relatives. Moreover, due to its geographical as well as quantitative vastness it's badly recorded or listed, and important parts of this heritage in both the countries have already been lost.

The result of what we might call an initial selection (because surely many modernist buildings in the two countries are not included in this collection) was obtained by archive and on field research personally performed in the two territories, US and Europe, in different libraries and archives.

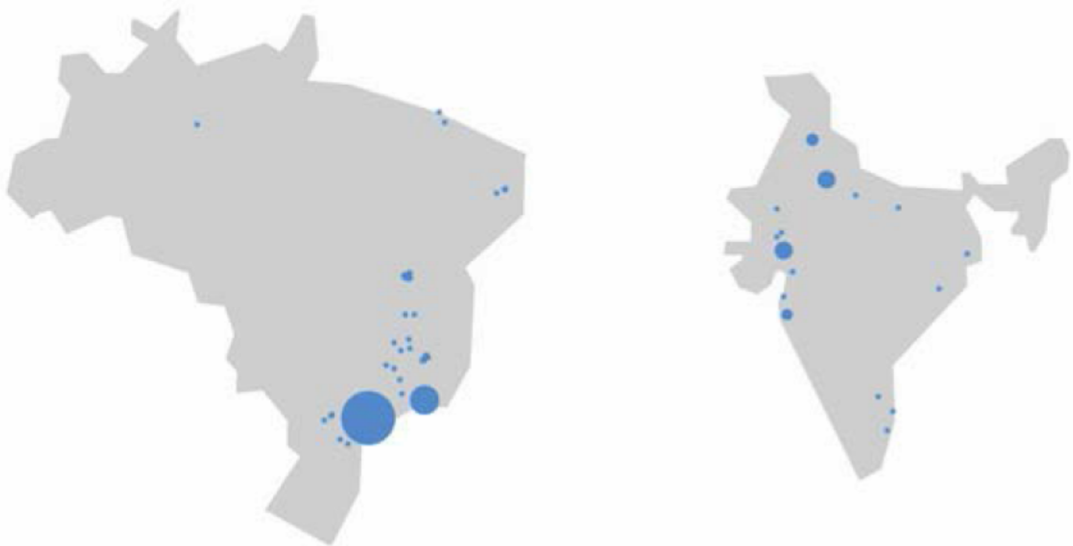


Image 7.1: Case studies locations in Brazil and India (same scale).

The magazines, monographies and drawings consulted allowed to deepen the knowledge on the phenomenon and to describe the most important modernist buildings in Brazil and India. In this framework also the geographical distribution was taken into consideration; despite the high concentration of modern buildings in big urban settlement of both the countries, architectures in small centre were identified as well in order to better describe the cultural footprint of this construction even in local environment.

Following the need of delimitate the research study within the boundaries of feasibility, three filters were applied to the database of buildings.
In this way it was possible to work out analyses, first sketches and drawings of one hundred buildings that were recorded and archived. Twenty buildings were then deeper analysed and on them applied a BIM procedure: these 3D models are now a great opportunity to develop studies and improve knowledge on some architects of that period and their legacy.
The third filter has been a final step toward the application of high technology tecniques on modern cultural heritage. The four buildings were identified in cooperation with local partner institutions thanks to capacity-building programmes and technology transfer seminars. Resources were found by international calls for proposal (i.e. the Getty Research Intitute *Keeping it modern* initiative) and the outputs were shared with all the partners.

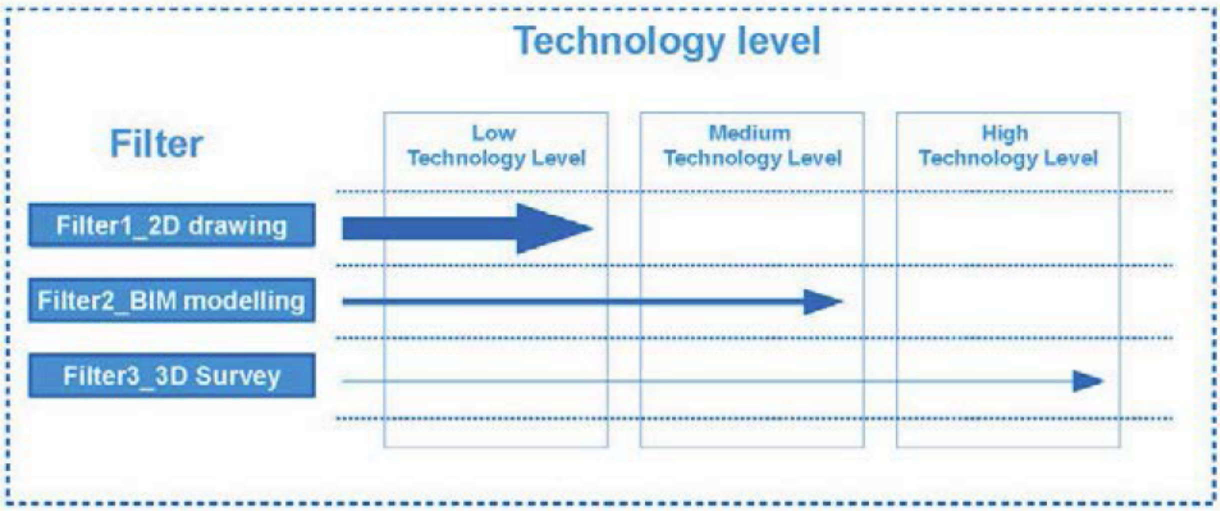


Figure 7.2: Technology level of filters (line thikness related to number of case studies per filter).

7.2 Filter 1: description and representation. Selection of 80 modern buildings

The first selection of 80 buildings has been implemented through a careful evaluation of the sources available both online and found in worldwide libraries and research centres. This framework shows buildings of different typology and size, built in dissimilar climate zone due to the vastness of the two countries. On these buildings, beside the application of project survey and redrawing techniques processes, the information collected allowed to basic evaluation about the possible level of danger in terms of preservation issues that the building is currently facing.
The overall situation related to each building was then expressed by a radar chart (6 axes) in the which 6 indicators were identified and evaluated giving them a mark from 1 to 10 case by case.

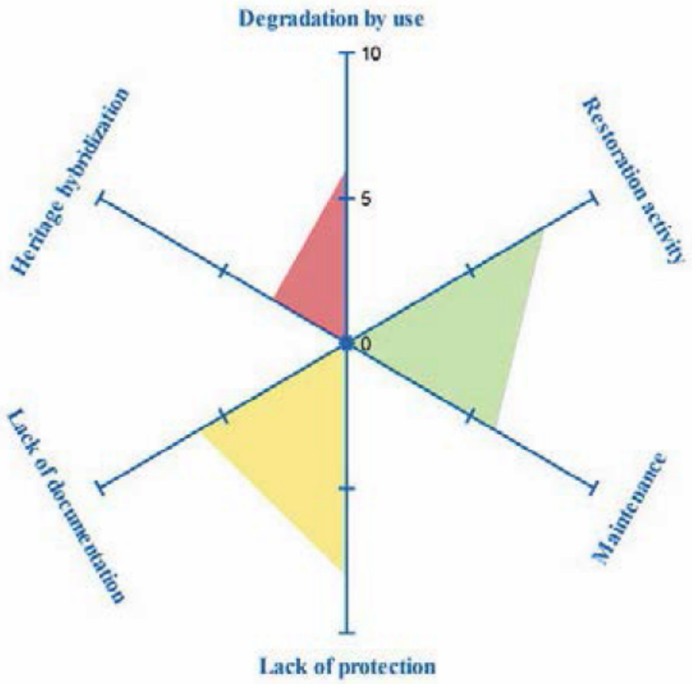


Figure 7.3: sample of radar chart for evaluation of the 80 case studies selected (filter 1).

The 3 couples of indicators identified by the areas in red (critical danger) yellow (moderate danger) and green (interventions toward their preservation) could highlight the overall preservation state of each identified building. The couples of indicators were made up trying to combine the main factors threatening the conservation of the modern heritage that the research was able to identify: the estimation of each level was then express through the grade.

“CRITICAL DANGER” (red colours)

Heritage hybridization (H. H)

There are many transformations challenging the modern cultural heritage in its evolution towards advanced modernity. Buildings adaptation to contemporary needs of space, light and ventilation could affect the integrity and quality. These manifestations comes naturally as homogenization, differentiation and, most especially, hybridization, as the concept of cultural heritage itself is historically constructed as a hybrid social product. The control over these phenomenon is essential to preserve modern heritage.
The indicator shows the level of hybridization of the building.

Degradation by use (D. U.)

Degradation by use can really affect the state of conservation of modern building. Some of them are currently used as public buildings (i.e. transportation hub, universities, retail complexes) with high people

flows during the day. In some cases, such as the public use as university venue (see FAU USP building in São Paulo), building have also to face vandalism phenomena and deliberate damages.
The indicator shows the level of degradation by use of the building.

"MODERATE DANGER" (yellow colours)

Lack of documentation (L. D.)

Proper documentation is essential at every stage of any research related to modern heritage but is also crucial towards it preservation and enhancement. If some institutions are producing a very big effort in order to conserve original drawings and picture of the most important architectures the majority of the hard sources are in danger. Digitalization processes are nowadays a key factor for the preservation of original design, shapes and materials.
The indicator shows the level of lack of documentation on the building.

Lack of protection (L. P.)

If many national and local authorities now include twentieth-century buildings in their listing programmes more work need to be done toward the by-law protection of this kind of heritage. Till now, both Brazil and India have been hesitating about protecting anything but the icons of the Modern era. In many areas, twentieth-century structures dominate the urban landscape thus, questions are raised about what to protect and how to establish comparative levels of significance within existing frameworks used in the heritage protection.
The indicator shows the level of lack of protection tools for the building.

"INTERVENTIONS" (green colours)

Maintenance (M.)

A positive aspect toward the preservation of modern heritage (but unfortunately encountered in few cases) is the implementation of maintenance activities. The uncertainties and complexities of the past have resulted in increased conservatism in the development of building performance and maintenance programmes. Subsequently, almost all maintenance programmes tend to display the symptoms of a dangerous delay: very often the actions are not calibrated, thus uneconomical, and maintenance programmes are too late, thus compromising the quality of the building.
The indicator shows the level of maintenance programmes for the building.

Restoration activity (R. A.)

The technical challenges posed by conserving twentieth-century places undoubtedly raise the most difficult philosophical conflicts. The move from craft to industrialized construction introduced many new materials, new uses for traditional materials, and component-based systems. These factors have resulted

in a building stock with a reduced life cycle. Even if maintenance is a key factor in order to avoid expensive restoration activities in some cases conservation project are indispensable for the preservation of modern heritage.
The indicator shows the level of restoration activity carried out on the building.

The combination of general information, pictures and the chart has brought to the identification of a possible grid for comparison and evaluation as shown in picture 7.4. Through this chart, it is possible to easily read the main characteristics of the building subject of study (each building of the first 250 selection has been codified: for Brazil BRxxx, for India INxxx) and also to individuate possible correlation to other similar buildings (same author, design, inspiration concept, etc…).
The correlation was an important part of research process as it clearly underline the spreading out of modernism principle among different designers at different time.

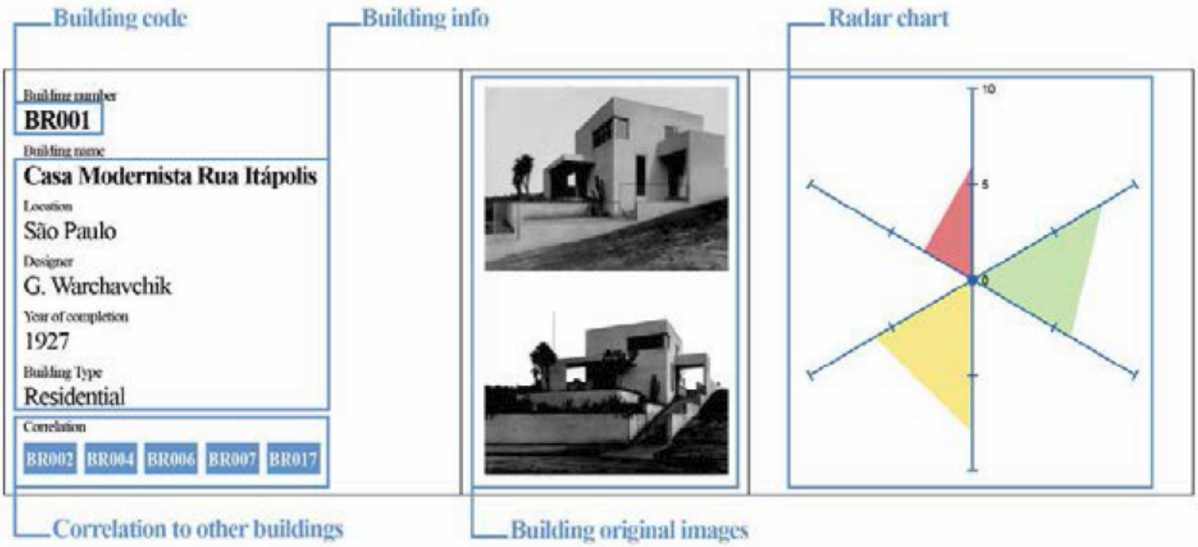
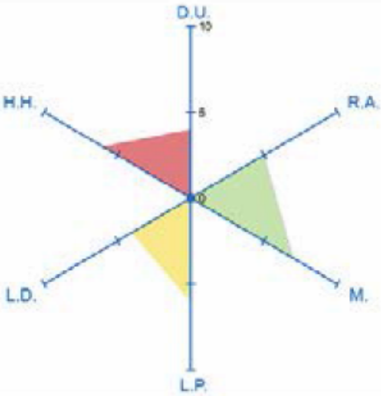
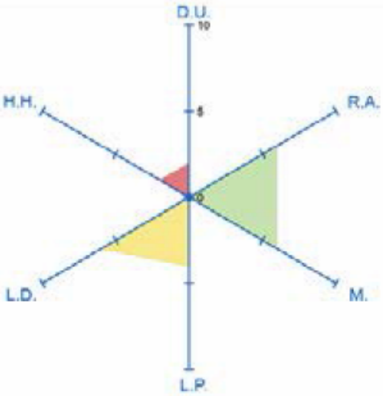
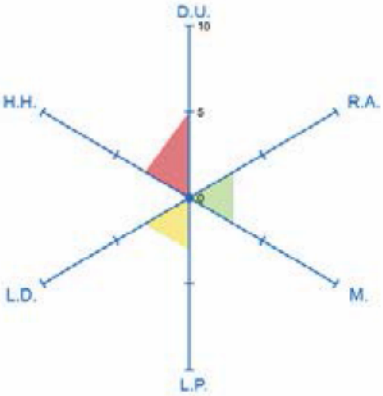
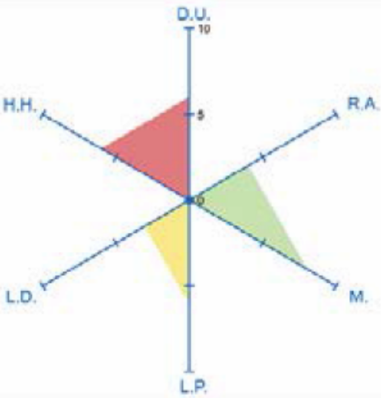


Figure 7.4: information layout for evaluation of the 80 case studies selected (filter 1).

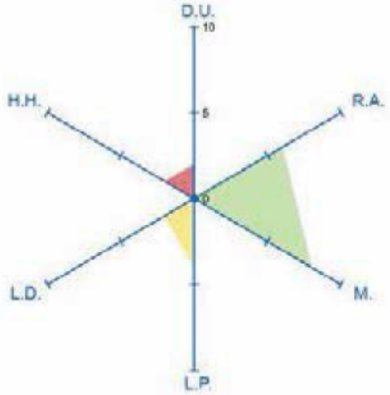
The selection of buildings that follows is trying to represent the different professionals at work in different regions of Brazil and India. Obviously it is dangerous to generalize statements and extrapolate valid concepts in well-defined contexts (many case studies are actually located in few areas, i.e. São Paulo, Rio de Janeiro, New Delhi and Ahmedabad).
At the same time the limited sources available (and the high concentration of modern building in some areas) and the vastness of the two countries have led to a more regional approach rather than a complete scenario which would have been absolutely uncontrollable for a PhD dissertation.

Description of selected buildings in Brazil

Building number **BR001** Building name **Casa Modernista Rua Itápolis** Location São Paulo Designer G. Warchavchik Year of completion 1927 Building Type Residential Correlation BR002 BR004 BR006 BR007 BR017	 	
Building number **BR020** Building name **Casa Saavedra** Location Petrópolis Designer L. Costa Year of completion 1940 Building Type Residential Correlation BR006 BR018 BR022 BR026 BR056	 	
Building number **BR034** Building name **Igreja de São Francisco** Location Belo Horizonte Designer O. Niemeyer Year of completion 1943 Building Type Religious Correlation BR015 BR019 BR027 BR028 BR029 BR033 BR078	 	
Building number **BR052** Building name **Hotel Jaraguá** Location São Paulo Designer F. Hepp Year of completion 1947 Building Type Tourism Correlation BR022 BR077 BR086 BR102 BR117	  	

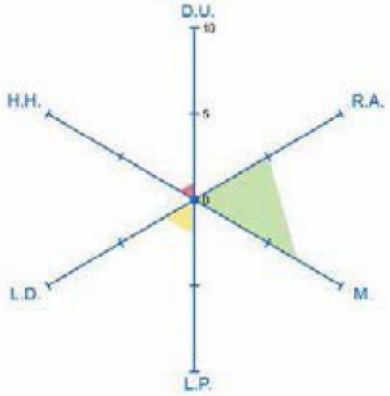
Building number
BR054
Building name
Residência Vilanova Artigas
Location
São Paulo
Designer
J. Vilanova Artigas
Year of completion
1948
Building Type
Residential
Correlation
BR037 BR040 BR060 BR061 BR119 BR168 BR178





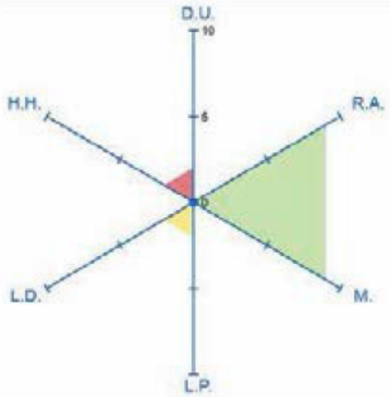
Building number
BR058
Building name
Casa de Vidro
Location
São Paulo
Designer
L. Bo Bardi
Year of completion
1949
Building Type
Residential
Correlation
BR118 BR124





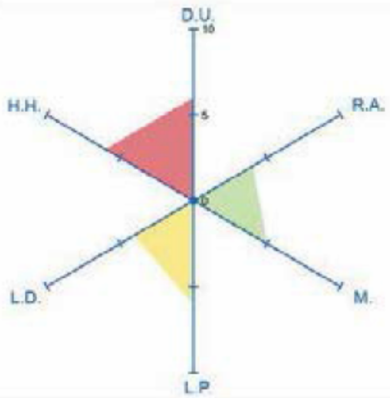
Building number
BR061
Building name
Casa Bettega
Location
Curitiba
Designer
J. Vilanova Artigas
Year of completion
1949
Building Type
Residential
Correlation
BR037 BR040 BR060 BR066 BR119 BR168 BR178





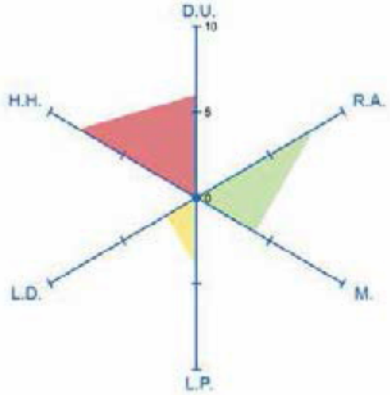
Building number
BR073
Building name
Rodoviaria de Londrina
Location
Londrina
Designer
J. Vilanova Artigas
Year of completion
1950
Building Type
Infrastructure
Correlation
BR013 BR014 BR144 BR145 BR146





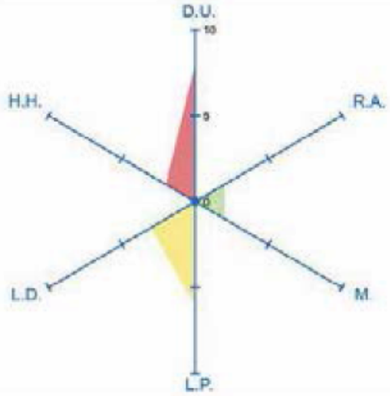
Building number
BR079
Building name
Edificio COPAN
Location
São Paulo
Designer
O.Niemeyer
Year of completion
1951
Building Type
Residential / Commercial
Correlation
BR010 BR015 BR039 BR045 BR097





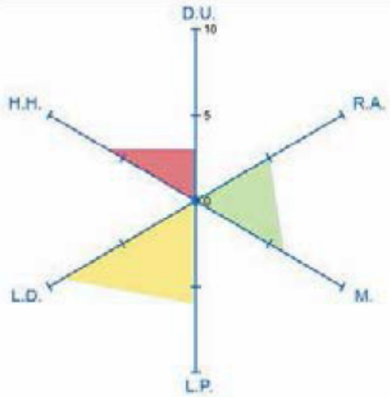
Building number
BR080
Building name
Residência Olivo Gomes
Location
São José dos Campos
Designer
R. Levi
Year of completion
1951
Building Type
Residential
Correlation
BR084 BR096 BR113 BR126 BR159





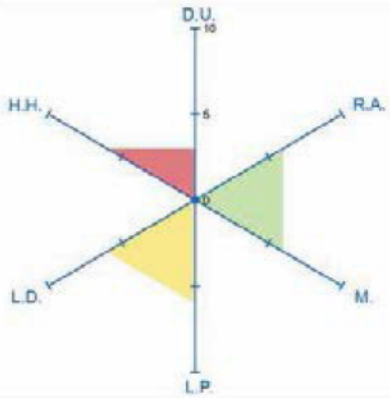
Building number
BR092
Building name
Casa Brandi
Location
Petrópolis
Designer
S. W. Bernardes
Year of completion
1952
Building Type
Residential
Correlation
BR025 BR083 BR087 BR142





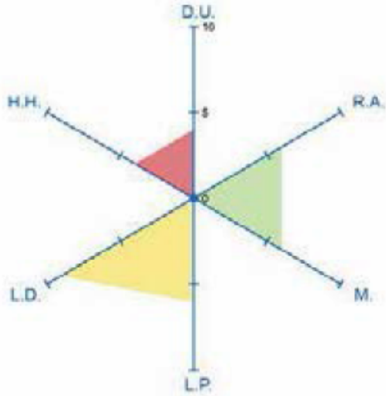
Building number
BR093
Building name
Residência Leonel Miranda
Location
Rio de Janeiro
Designer
O. Niemeyer
Year of completion
1952
Building Type
Residential
Correlation
BR032 BR033 BR036 BR062 BR101 BR105





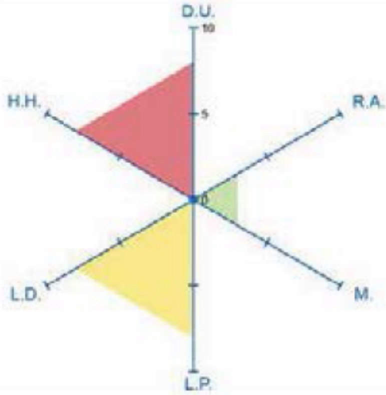
Building number
BR096
Building name
Residência Paulo Hess
Location
São Paulo
Designer
L. Roberto C. Franco, R. Levi, R. C. César
Year of completion
1952
Building Type
Residential
Correlation
BR010 BR015 BR039 BR045 BR097





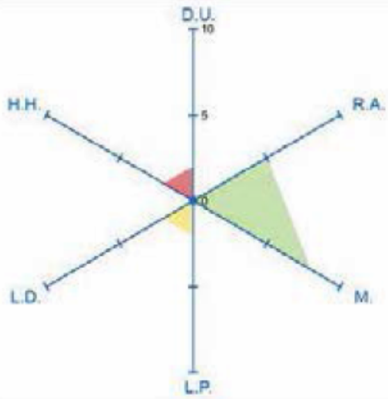
Building number
BR098
Building name
Colégio Estadual da Penha
Location
São Paulo
Designer
E. Corona
Year of completion
1952
Building Type
Cultural
Correlation
BR042 BR103 BR145





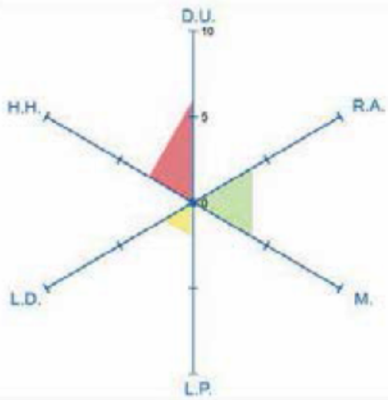
Building number
BR100
Building name
Museu de arte moderna de Rio
Location
Rio de Janeiro
Designer
A. Reidy
Year of completion
1953
Building Type
Cultural
Correlation
BR015 BR045 BR097 BR118 BR145





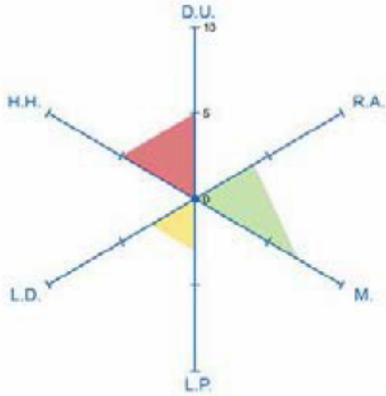
Building number
BR101
Building name
Casa das Canoas
Location
Rio de Janeiro
Designer
O. Niemeyer
Year of completion
1953
Building Type
Residential
Correlation
BR032 BR033 BR036 BR062 BR093





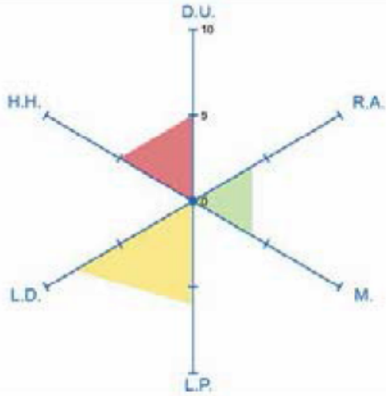
Building number
BR106
Building name
Conjunto Nacional
Location
São Paulo
Designer
D. Libeskind
Year of completion
1954
Building Type
Commercial
Correlation
BR089 BR094 BR111 BR122





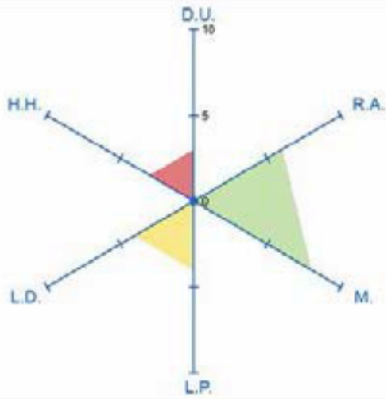
Building number
BR112
Building name
Casa na rua Suécia
Location
São Paulo
Designer
O. A. Bratke
Year of completion
1956
Building Type
Residential
Correlation
BR085 BR091 BR099 BR128





Building number
BR117
Building name
Edifício Itália
Location
São Paulo
Designer
F. Hepp
Year of completion
1956
Building Type
Commercial
Correlation
BR052 BR064 BR116 BR175

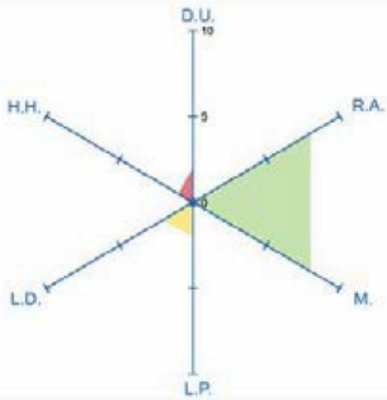


Building number
BR118
Building name
MASP Museu de Arte de São Paulo
Location
São Paulo
Designer
L. Bo Bardi
Year of completion
1957
Building Type
Cultural

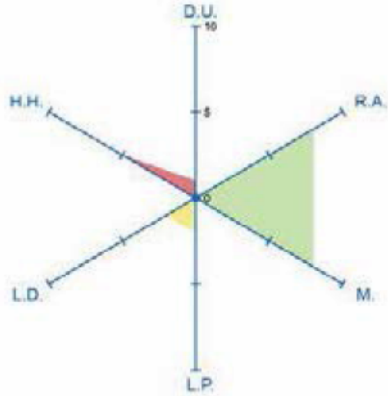
BR100





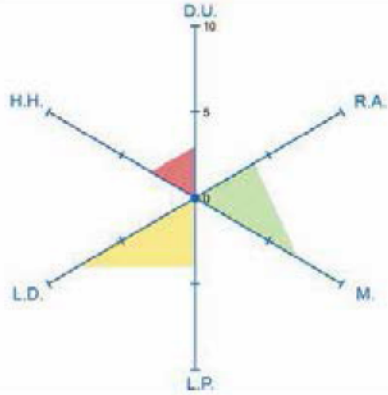
Building number
BR119
Building name
Residência Olga Baeta
Location
São Paulo
Designer
C. Cascaldi, J. Vilanova Artigas
Year of completion
1957
Building Type
Residential
Correlation
BR066 BR133 BR141





Building number
BR122
Building name
Residência Antonio Mauricio da Rocha
Location
São Paulo
Designer
D. Libeskind
Year of completion
1957
Building Type
Residential
Correlation
BR089 BR094 BR111

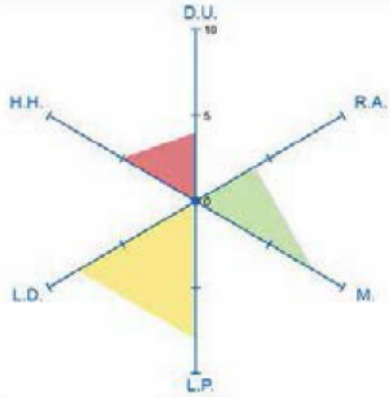




Building number
BR124
Building name
Casa Jardim do Cristal
Location
São Paulo
Designer
L. Bo Bardi
Year of completion
1958
Building Type
Residential

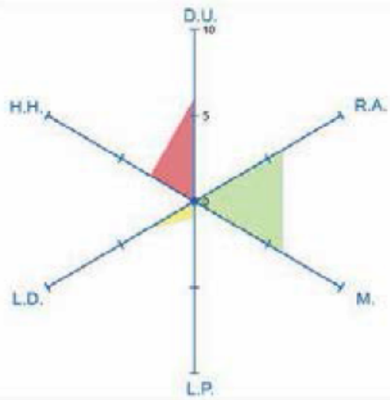
BR058



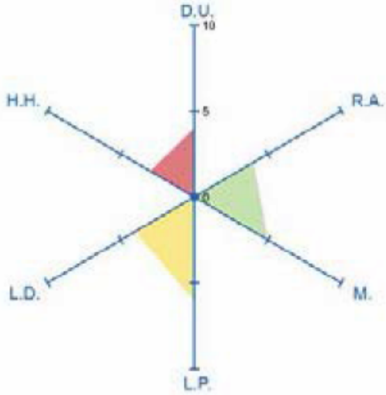


Building number
BR125
Building name
Catedral de Brasilia
Location
Brasilia
Designer
O.Niemeyer
Year of completion
1958
Building Type
Religious
Correlation
BR034 BR078 BR114 BR115 BR131 BR132

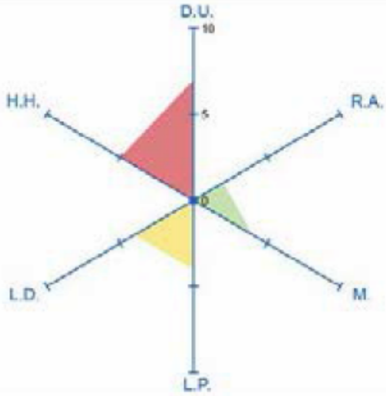




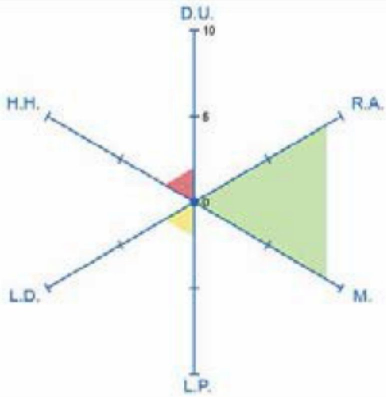
Building number
BR129
Building name
Residência Antonio Cunha Lima
Location
São Paulo
Designer
J. Guedes
Year of completion
1958
Building Type
Residential
Correlation
BR149 BR155 BR162 BR164 BR183 BR186 BR196



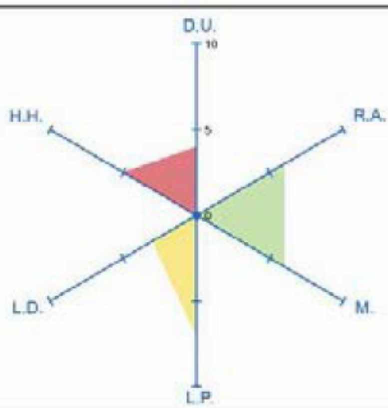
Building number
BR130
Building name
Ginásio do Atlético Paulistano
Location
São Paulo
Designer
P. Mendes da Rocha
Year of completion
1958
Building Type
Sport
Correlation
BR151 BR152



Building number
BR132
Building name
Palácio do Itamaraty
Location
Brasilia
Designer
O. Niemeyer
Year of completion
1959
Building Type
Government
Correlation
BR015 BR114 BR131

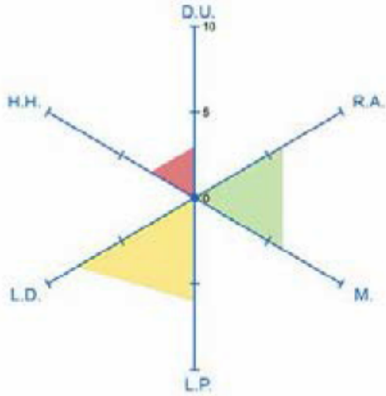


Building number
BR136
Building name
Banco Sul Americano do Brasil S.A.
Location
São Paulo
Designer
R. Levi
Year of completion
1960
Building Type
Commercial
Correlation
BR049 BR160 BR161 BR175



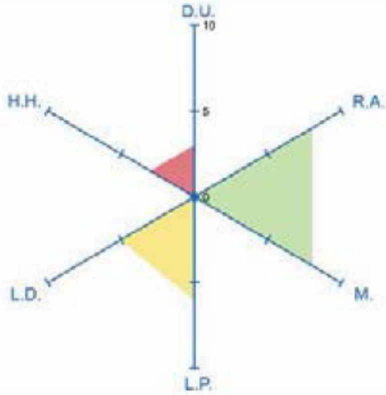
Building number
BR138
Building name
Casa Celso Silveira Mello
Location
São Paulo
Designer
P. Mendes da Rocha
Year of completion
1960
Building Type
Residential
Correlation
BR156 BR172 BR181 BR190 BR192





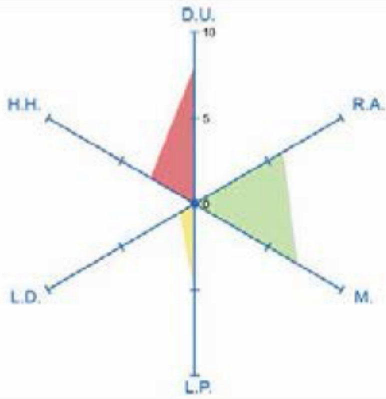
Building number
BR139
Building name
Residência Roberto Millan
Location
São Paulo
Designer
C. Milan
Year of completion
1960
Building Type
Residential
Correlation
BR140 BR154





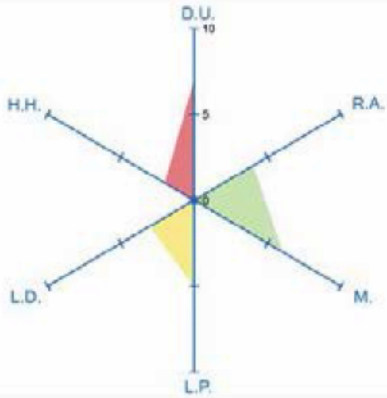
Building number
BR145
Building name
Facultade de arquitetura e urbanismo USP
Location
São Paulo
Designer
J. Vilanova Artigas, C. Cascaldi
Year of completion
1961
Building Type
Educational
Correlation
BR143 BR144 BR146

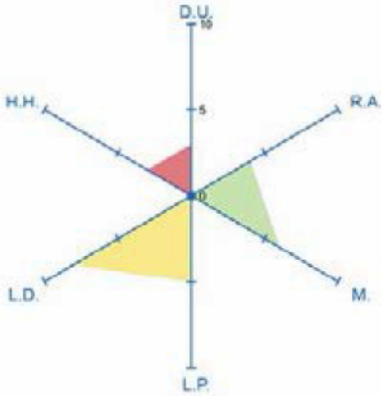
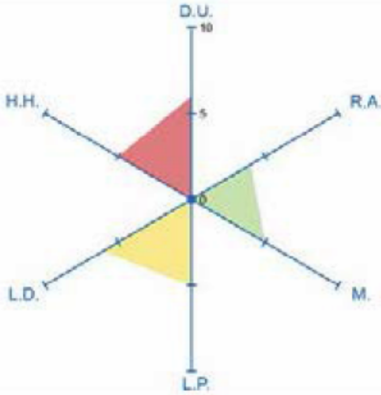
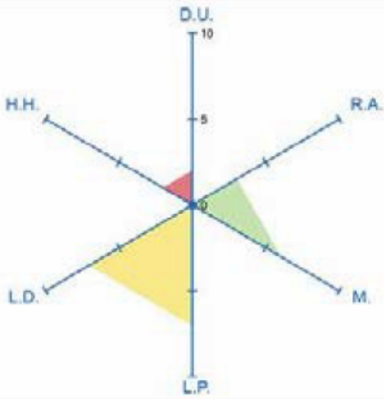
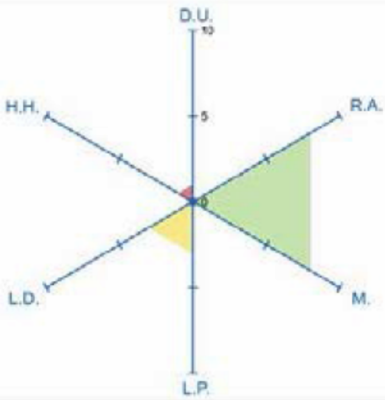




Building number
BR146
Building name
Rodoviária de Jaú
Location
São Paulo
Designer
J. Vilanova Artigas, C. Cascaldi
Year of completion
1961
Building Type
Infrastructure
Correlation
BR073 BR143 BR144 BR145

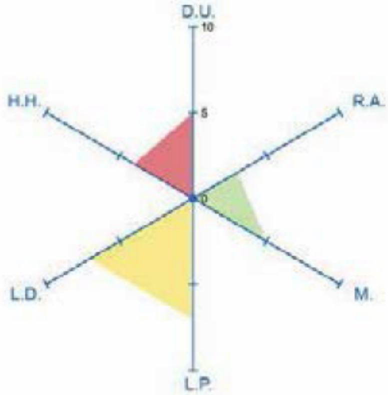




Building number **BR150** Building name **Residência Abram Jagle** Location São Paulo Designer J. W. Toscano Year of completion 1961 Building Type Residential Correlation BR140 BR154	 	
Building number **BR152** Building name **Fórum de Avaré** Location Avaré Designer P. Mendes da Rocha Year of completion 1962 Building Type Government Correlation BR130 BR151	 	
Building number **BR154** Building name **Residência Antônio D'Elboux** Location São Paulo Designer C. Millan Year of completion 1962 Building Type Residential Correlation BR139 BR140	 	
Building number **BR156** Building name **Residência Paulo Mendes da Rocha** Location São Paulo Designer P. Mendes da Rocha Year of completion 1964 Building Type Residential Correlation BR138 BR172 BR181 BR190 BR192	 	

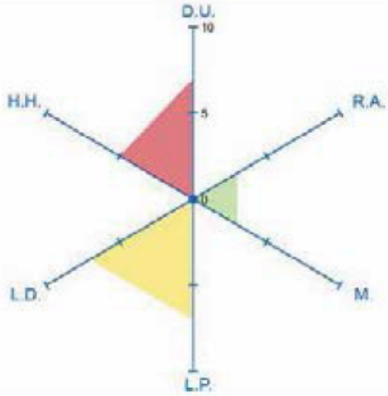
Building number
BR157
Building name
Residência Siegbert Zanettini
Location
São Paulo
Designer
S. Zanettini
Year of completion
1964
Building Type
Residential
Correlation





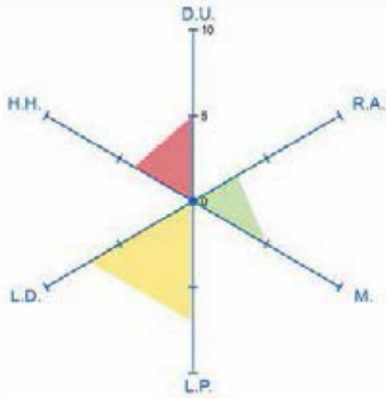
Building number
BR158
Building name
Residência Rosa Okubo
Location
Avaré
Designer
R. Ohtake
Year of completion
1964
Building Type
Residential
Correlation
BR165 BR169 BR180





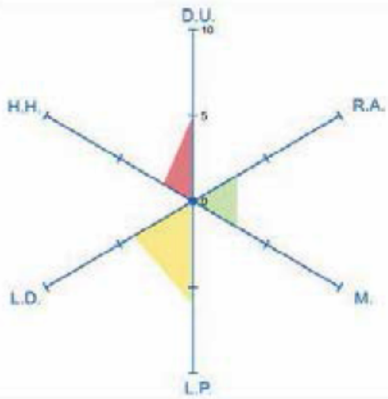
Building number
BR163
Building name
Residência Tereza Martino
Location
São Paulo
Designer
A. Martino
Year of completion
1965
Building Type
Residential
Correlation





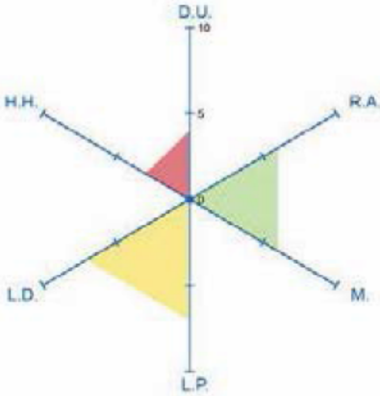
Building number
BR165
Building name
Residência Tomie Ohtake
Location
São Paulo
Designer
R. Ohtake
Year of completion
1966
Building Type
Residential
Correlation
BR158 BR169 BR180





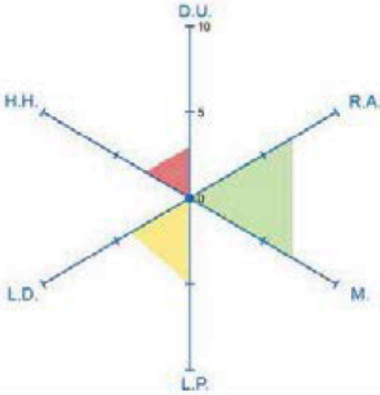
Building number
BR167
Building name
Casa Manoel Mendes André
Location
São Paulo
Designer
J. Vilanova Artigas
Year of completion
1966
Building Type
Residential
Correlation
BR037 BR040 BR060 BR061 BR119 BR168 BR178





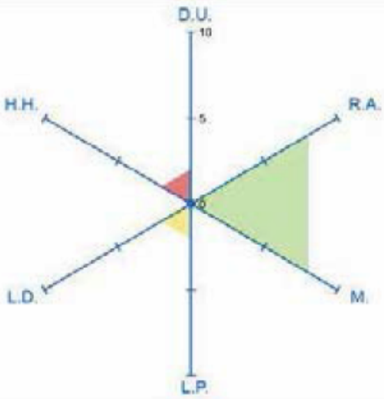
Building number
BR168
Building name
Casa Elza Salvatori Berquó
Location
São Paulo
Designer
J. Vilanova Artigas
Year of completion
1967
Building Type
Residential
Correlation
BR037 BR040 BR060 BR061 BR119 BR167 BR178





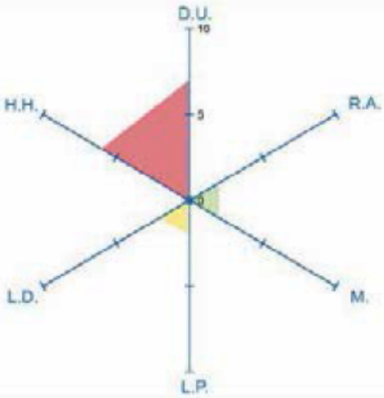
Building number
BR169
Building name
Residência Chiyo Hama
Location
São Paulo
Designer
R. Ohtake
Year of completion
1967
Building Type
Residential
Correlation
BR158 BR165 BR180





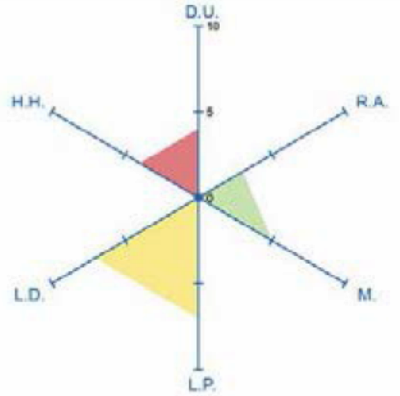
Building number
BR170
Building name
Residência Telmo Porto
Location
São Paulo
Designer
J. Vilanova Artigas
Year of completion
1968
Building Type
Residential
Correlation
BR037 BR040 BR060 BR061 BR119 BR167 BR178





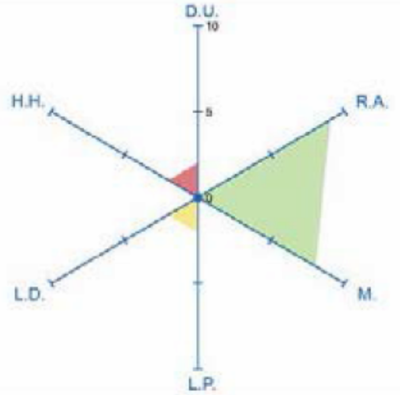
Building number
BR171
Building name
Residência Juarez Brandão Lopes
Location
São Paulo
Designer
R. Léfèvre, F. Império
Year of completion
1968
Building Type
Residential
Correlation





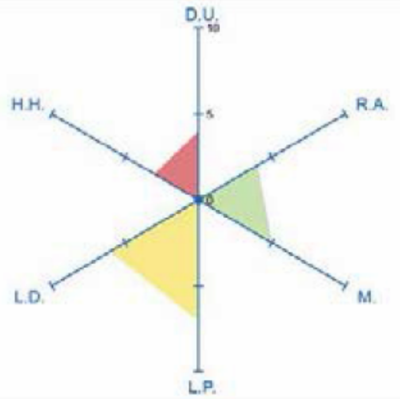
Building number
BR175
Building name
Edifício-Sede da FIESP-CIESP-SESI
Location
São Paulo
Designer
R. Levi
Year of completion
1969
Building Type
Commercial
Correlation
BR049 BR106 BR136





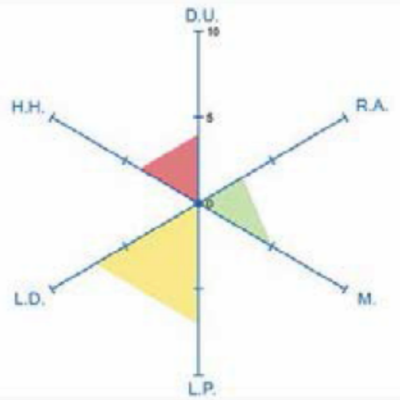
Building number
BR176
Building name
Residência Jon Maitrejean
Location
São Paulo
Designer
J. Maitrejean
Year of completion
1969
Building Type
Residential
Correlation





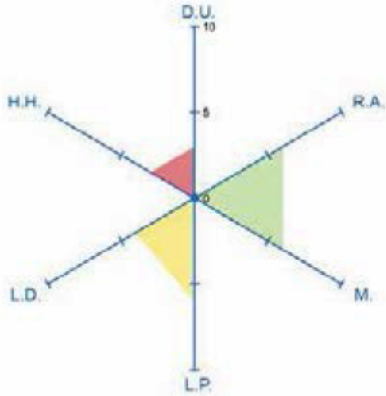
Building number
BR179
Building name
Residência Waldo Perseu Pereira
Location
São Paulo
Designer
J. Guedes
Year of completion
1969
Building Type
Residential
Correlation
BR121 BR129 BR149 BR155 BR162 BR174 BR183





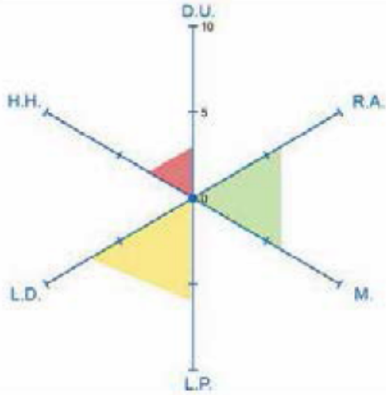
Building number
BR180
Building name
Residência Nadir Zacharias
Location
São Paulo
Designer
R. Ohtake
Year of completion
1970
Building Type
Residential
Correlation
BR158 BR165 BR169





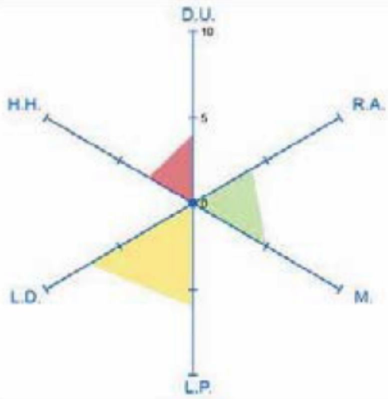
Building number
BR181
Building name
Residência Fernando Millan
Location
São Paulo
Designer
P. Mendes da Rocha
Year of completion
1970
Building Type
Residential
Correlation
BR138 BR190 BR192





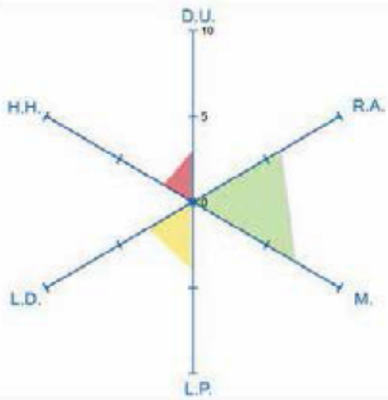
Building number
BR182
Building name
Residência Paulo Bastos
Location
São Paulo
Designer
P. Bastos
Year of completion
1970
Building Type
Residential
Correlation





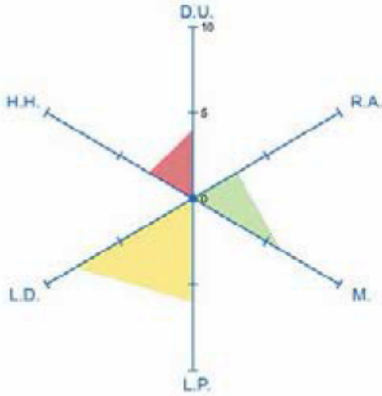
Building number
BR183
Building name
Residência Liliana Guedes
Location
São Paulo
Designer
J. Guedes
Year of completion
1969
Building Type
Residential
Correlation
BR121 BR129 BR149 BR155 BR162 BR174 BR179





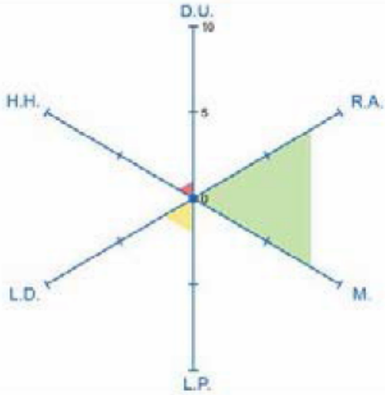
Building number
BR188
Building name
Residência Janne Ottoni
Location
São Paulo
Designer
Da. Ottoni, Dá. Ottoni
Year of completion
1971
Building Type
Residential
Correlation





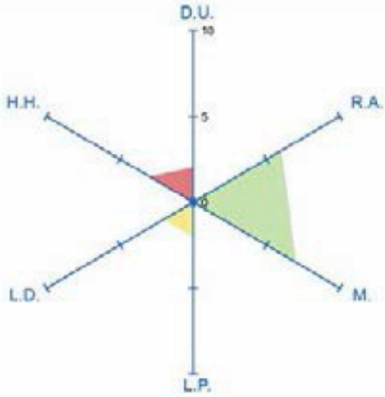
Building number
BR189
Building name
Residência Millan
Location
São Paulo
Designer
M. Acayaba
Year of completion
1972
Building Type
Residential
Correlation





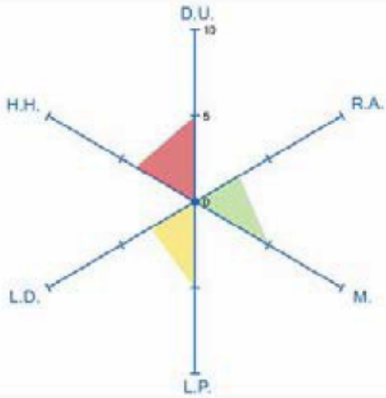
Building number
BR190
Building name
Residência James King
Location
São Paulo
Designer
P. Mendes da Rocha
Year of completion
1972
Building Type
Residential
Correlation
BR176 BR181 BR192





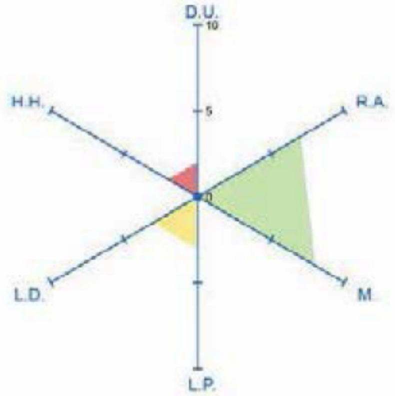
Building number
BR191
Building name
Residência José da Silva Netto
Location
Brasilia
Designer
J. Filgueiras Lima
Year of completion
1973
Building Type
Residential
Correlation
BR198





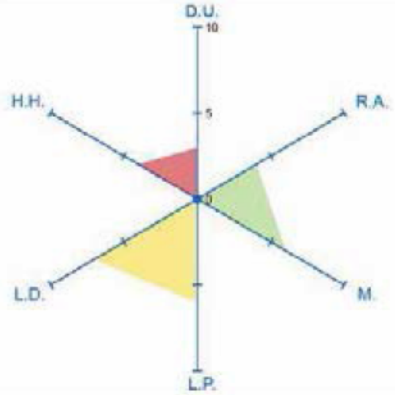
Building number
BR192
Building name
Casa Gerber
Location
Angra dos Reis
Designer
P. Mendes da Rocha
Year of completion
1973
Building Type
Residential
Correlation
BR156 BR172 BR181 BR190





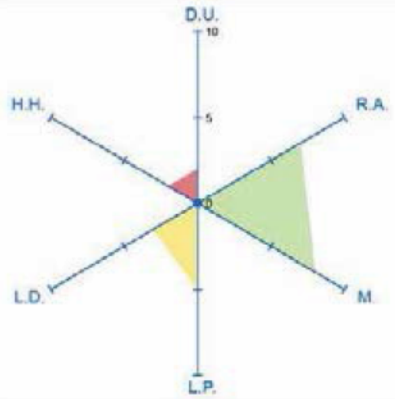
Building number
BR193
Building name
Residência Edgar Gonçalves Dente
Location
São Paulo
Designer
E. Gonçalves Dente
Year of completion
1974
Building Type
Residential
Correlation





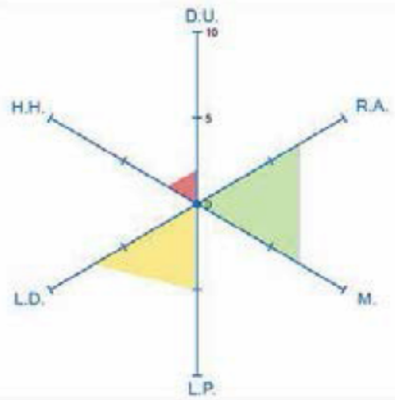
Building number
BR194
Building name
Residência Antonio Teófilo de Andrade Hort
Location
São Paulo
Designer
D. Tozzi
Year of completion
1974
Building Type
Residential
Correlation



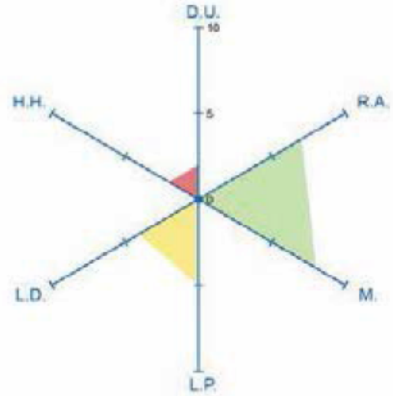


Building number
BR195
Building name
Residência Edgard Niclewicz
Location
Curitiba
Designer
J. Vilanova Artigas
Year of completion
1974
Building Type
Residential
Correlation
BR037 BR040 BR060 BR061 BR119 BR167 BR178

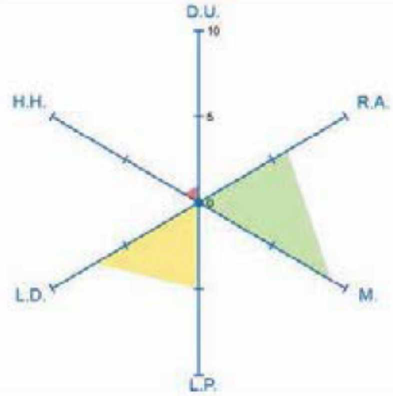




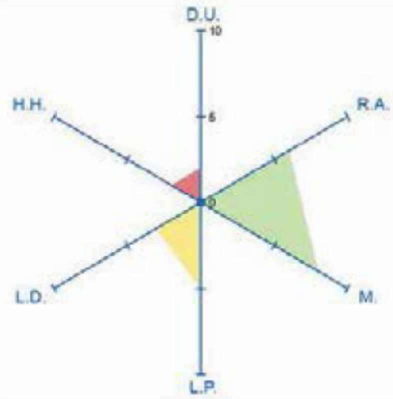
Building number
BR196
Building name
Residência Fabricio Beer
Location
São Paulo
Designer
J. Guedes
Year of completion
1976
Building Type
Residential
Correlation
BR121 BR129 BR149 BR145 BR162 BR164 BR197



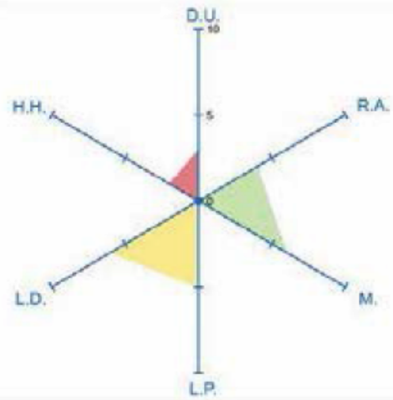
Building number
BR197
Building name
Residência Anna Mariani Ibiuna
Location
São Paulo
Designer
J. Guedes
Year of completion
1977
Building Type
Residential
Correlation
BR121 BR029 BR149 BR179 BR183 BR186 BR196



Building number
BR198
Building name
Residência Nivaldo Borges
Location
Brasilia
Designer
J. Filgueiras Lima
Year of completion
1978
Building Type
Residential
Correlation
BR191



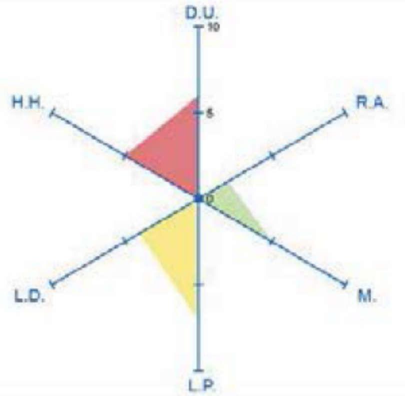
Building number
BR199
Building name
Residência Max Define
Location
São Paulo
Designer
E. de Almeida
Year of completion
1978
Building Type
Residential
Correlation



Description of selected buildings in India

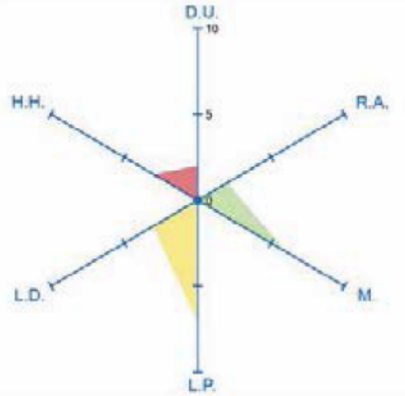
Building number
IN001
Building name
Golconde housing
Location
Pondicherry
Designer
A. Rymond
Year of completion
1936
Building Type
Residential
Correlation





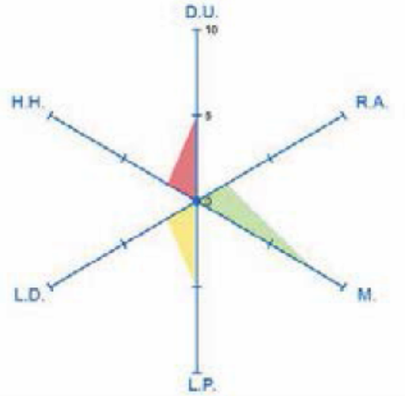
Building number
IN005
Building name
Shodhan House
Location
Ahmedabad
Designer
Le Corbusier
Year of completion
1951
Building Type
Residential
Correlation
IN006 IN009 IN012 IN017





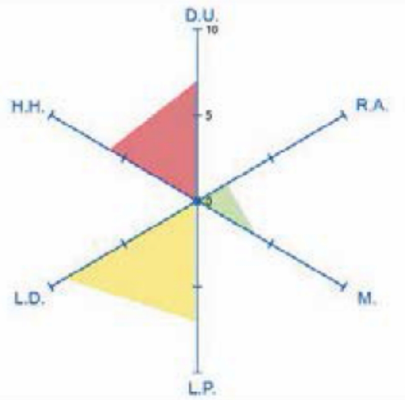
Building number
IN006
Building name
Mill Owners' Association Building
Location
Ahmedabad
Designer
Le Corbusier
Year of completion
1951
Building Type
Commercial
Correlation
IN005 IN009 IN012 IN017

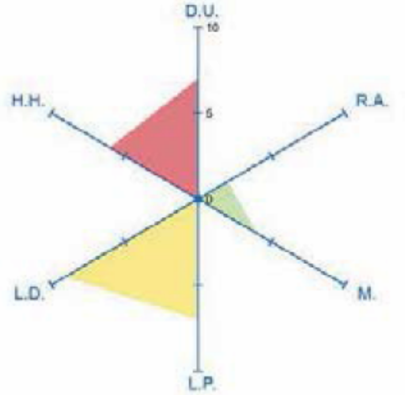
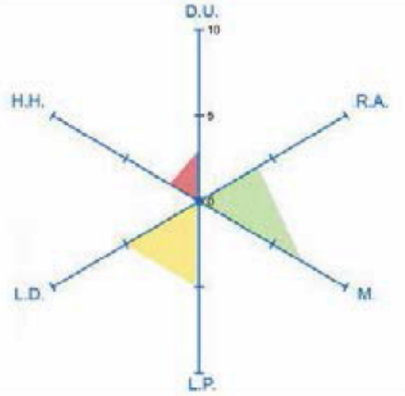
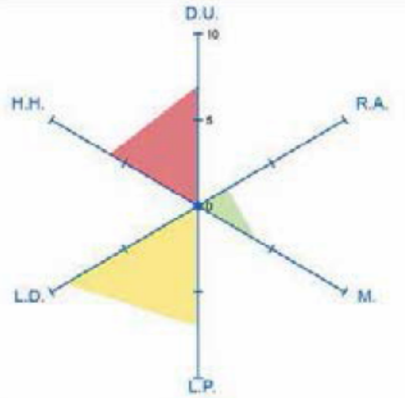
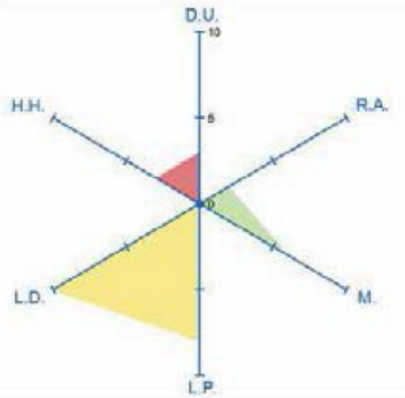




Building number
IN007
Building name
House Type 5J
Location
Chandigarh
Designer
P. Jeanneret
Year of completion
1951
Building Type
Residential
Correlation
IN008 IN010 IN011

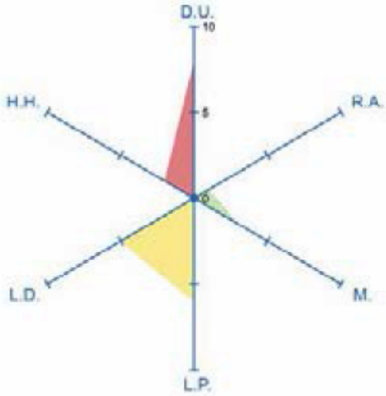




Building number **IN008** Building name **House Type 4J** Location Chandigarh Designer P. Jeanneret Year of completion 1951 Building Type Residential Correlation IN007 IN010 IN011	 	
Building number **IN009** Building name **Sarabhai House** Location Ahmedabad Designer Le Corbusier Year of completion 1951 Building Type Residential Correlation IN005 IN009 IN012 IN017	 	
Building number **IN010** Building name **House Type 6J** Location Chandigarh Designer P. Jeanneret Year of completion 1951 Building Type Residential Correlation IN007 IN008 IN011	 	
Building number **IN011** Building name **House for Minister** Location Chandigarh Designer P. Jeanneret Year of completion 1951 Building Type Residential Correlation IN007 IN008 IN010	 	

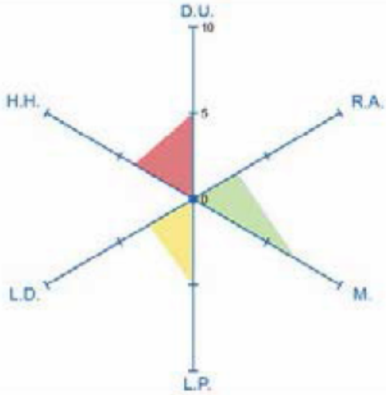
Building number
IN013
Building name
B.M. Institute of Mental Health
Location
Ahmedabad
Designer
G. Sarabhai
Year of completion
1951
Building Type
Cultural
Correlation
IN029





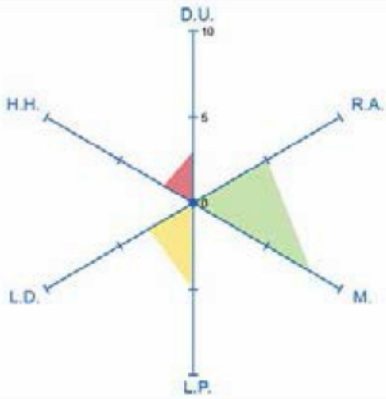
Building number
IN029
Building name
National Institute of Design
Location
Ahmedabad
Designer
Ga. Sarabhai, Gi. Sarabhai
Year of completion
1961
Building Type
Educational
Correlation
IN013 IN021 IN031 IN032





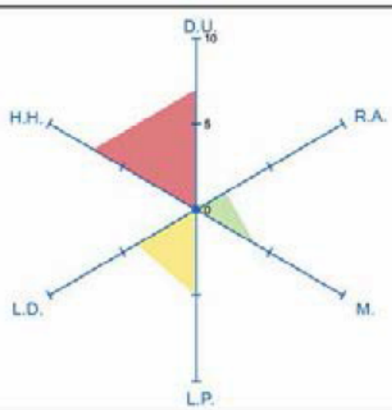
Building number
IN030
Building name
Ramkrishna House
Location
Ahmedabad
Designer
C. Correa
Year of completion
1962
Building Type
Residential
Correlation
IN034 IN040 IN048





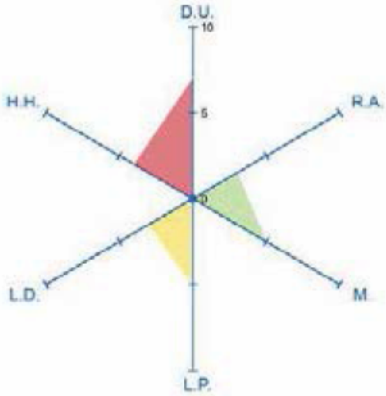
Building number
IN031
Building name
Indian Institute of Management
Location
Ahmedabad
Designer
L. I. Kahn
Year of completion
1962
Building Type
Educational
Correlation
IN029 IN032 IN021





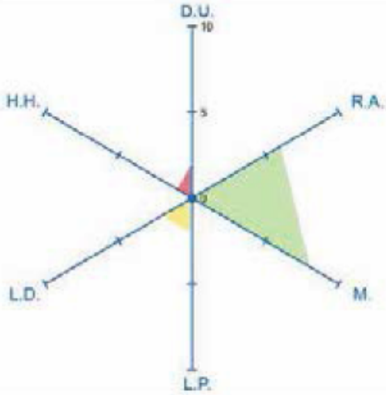
Building number
IN032
Building name
CEPT University
Location
Ahmedabad
Designer
B. Doshi
Year of completion
1962
Building Type
Educational
Correlation
IN018 IN019 IN029 IN031 IN032





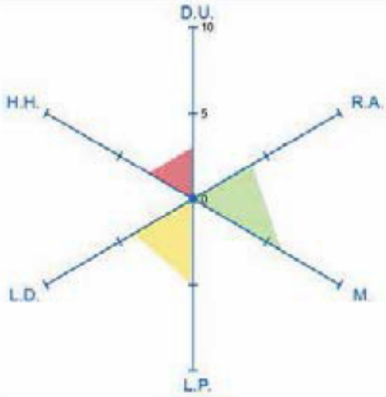
Building number
IN034
Building name
Gandhi Ashram
Location
Ahmedabad
Designer
C. Correa
Year of completion
1963
Building Type
Cultural
Correlation
IN040 IN048





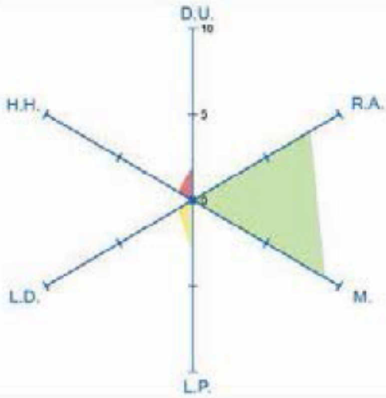
Building number
IN040
Building name
Pareck House
Location
Ahmedabad
Designer
C. Correa
Year of completion
1967
Building Type
Residential
Correlation
IN034 IN048





Building number
IN057
Building name
Sangath complex
Location
Ahmedabad
Designer
B. Doshi
Year of completion
1978
Building Type
Commercial / Cultural
Correlation
IN018 IN019 IN032





7.3 Filter 2: 3D analyses and representation. Selection of 25 buildings

The selection process of 25 modern buildings both in Brazil and India was based on the residential typology. This was because thinking about the way of living means arising questions about the shape of the urban fabric, the building type, building models, sustainability and management of intervention for a savings of resources over time, but it also means defining the expressive criteria which relate the environment, the natural landscape and cities.

Housing was an important area of the design experience for all the modernist architect not only because the stronger relation between the professional and the client, but also because designing houses at that time (and also nowadays) means to enter into the heart of innovation in design and technology and in direct contact with the real estate market strategies.

Knowledge of the modernist housing stock is an essential element for the architectural design knowledge of that period.

Through the reading of examples of the residential built quality is possible to analyse the dynamics of the urban fabric and the acquiring compositional design and technological elements, that have allowed us to evaluate the morphological evolution and offered an opportunity for a methodological comparison.

From the 3D models analyses, beside the information related to building and plot size, typology and roof type, it has been possible to highlight some indicators which can be used in order to have a clear picture about the buildings morphology and main factors that could threaten its conservation.

Thus 3 main areas (macro groups) of critical factors for building conservation have been identified in technological, natural and urban (listed in order of importance).

Inside these 3 areas the selected indicators were 9, and their consideration has been carefully evaluated starting from the acknowledge of potential dangerous conditions for the building.

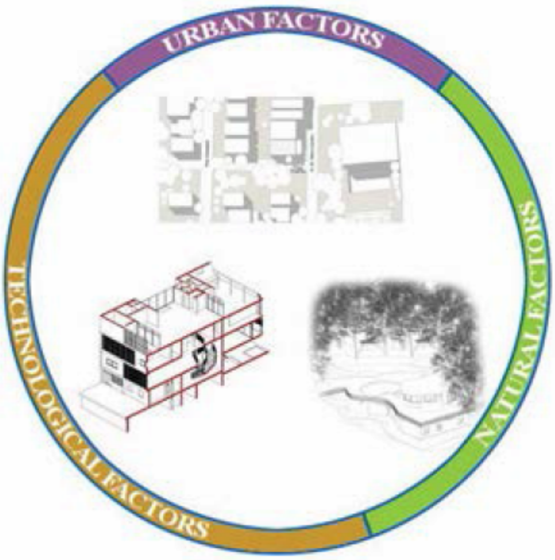


Figure 7.5: the 3 macro groups of indicators chosen (filter 2).

For what concerns the3 macro groups of indicators, the study has highlighted how the most important area of factors threatening the conservation of modern cultural heritage is strongly linked with the building characteristics. **Technological factors** could actually be an obstacle in conservation processes and even during the general maintenance of these buildings. For instance the industrialized construction introduced many new materials, new uses for traditional materials, and component-based systems.

Traditional detailing was abandoned, and it was often claimed that buildings were maintenance free. In the fiscally austere post-war era, limited budgets and shortages of materials such as steel and timber, together with the de-skilling of the building industry, meant that building quality was sometimes compromised. These factors have resulted in a building stock with a reduced life cycle (MCDONALD, 2013).

Figure 7.6: Casa Olivo Gomes by Rino Levi: the innovative window sliding system are not so easy to be restored.

A second range of indicators could be selected among the **natural factors**. We should keep in mind that Brazil and India are tropical countries which climate and vegetation could be very aggressive toward cultural heritage. For instance monsoon period brings to India early more rain than in every European country and this strongly affect the material resilience. The same could be stressed also for some area of Brazil, where rain are strong in wet seasons. Undoubtedly some recent collapses of cultural heritage in these countries have been caused by the uncontrolled vegetation growth (roots and branches can badly damage the structures).

Furthermore as vegetation is sometimes more protected than buildings it is not always easy to deal with their replacement or even their pruning. In some cases natural characteristics of the site such as orography can also be an obstacle toward the site conservation.

Figure 7.7: Casa de Vidro by Lina Bo Bardi: the vegetation growth is weakening the garden concrete/stone walls by roots action.

Furthermore are worthy of consideration also the **urban factors** that can led to the bad conservation of a modern building or even to its destruction in case the urban economic pressure is unbearable for the owner. This is the case where, especially in high developing countries, the need of space in valuable area puts some modern buildings in danger. If not adequately protected by-law these architecture could be demolished and replaced by tallest buildings to be sold on the building market, a huge business both in Brazil and in India.

Figure 7.8: Casa Bettega in Curitiba by Vilanova Artigas: high rise building were built all around it.

For each of the 25 selected buildings was then conceived a table containing different level of information. Beside the building code, it has been possible through digital enquiring on 3D model to achieve an accurate definition of the total surface of plot area and of the buildings levels.

Material and roof type were also catalogued as they are an important factor for the conservation and maintenance approach. The Kiviat chart was then integrated and divided into sectors representing the three main families of factors that can generate difficulties toward the reservation of these buildings.

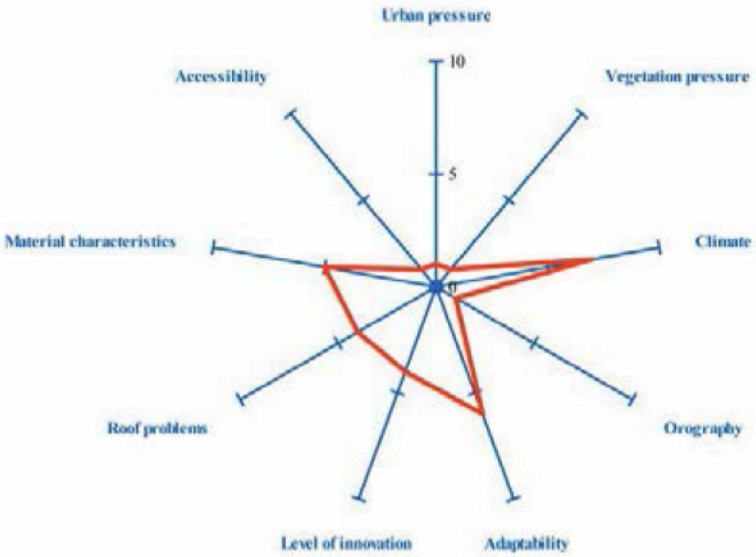


Figure 7.9: Kiviat chart for analyses of 25 case studies selected (filter 2).

For each indicator a grade from 1 to 10 was expressed in order to have a clear picture of the whole building. Lowe marks means low level of impediment for the building conservation.

The indicators were then correlated using a Kiviat Chart (or Kiviat diagram) a radar chart able to graphically display data in the form of a two-dimensional chart of different quantitative variables represented on axes starting from the same point. The relative position and angle of the axes is uninformative for this research.

TECHNOLOGICALFACTORS

Material characteristics

For what concerns the building materials, it is important to emphasize that the analysis of the constructed work does not reveal very well the adversities that occurred during the design process and its construction. In many cases the choices were made both for functional and technical constructive aspects, or aesthetic and conceptual aspects. Furthermore nowadays we know that the choice of a material was sometimes based simply on its availability.

Over the last decades there have been limited advances in developing and adapting repair methods to modern building materials. It has become evident that in some cases repair is not possible, and large-scale replacement or even reconstruction may be necessary.

The indicator shows the level of possible difficulties for both maintenance and restoration works.

Roof problems

Roof has been an important aspect in modernist design, and it gains especially in Brazil new value and importance (see the extensive use of the butterfly type roof or vaulted roof). In many cases, the choice of a type of roof resulted from the limitations encountered at the time of its construction, and does not reveal the real thought of the designer. Until the 1950s, cement and steel were not effortlessly available for the construction in several medium-sized Brazilian and Indian cities, which made its execution difficult and in some case not properly worked out. In many buildings in both the countries leaking water from the roof is one of the main causes of deterioration.

The indicator shows the level of problems related to roof maintenance and restoration.

Level of innovation

Some of the describe buildings presents a level of innovation very high for that time. Brazilian and Indian architects were experimenting new techniques and material application. Currently costs of repair versus replacement is unfortunately an argument used against conservation. The combination of an high level of innovation and bad application of construction materials has already brought to the loss of some architecture of this period.

The indicator shows the level of innovation which could be an obstacle in case of restoration works.

Adaptability

Adaptation is an important feature for the preservation of a part of the modernist built heritage. In some cases for new uses or new functional requirements difficulties emerged, but it is important not to single out modern buildings as the only ones facing these issues, for to do so would likely reduce support for their protection and conservation. Adaptive reuse (for institutional, foundation or museum purposes) could be a key factor for the preservation of some modern buildings. Good solutions are already there and they demonstrates the ways in which difficult issues have been managed.

The indicator shows the level of difficulties that could be faced in case of adaptability or re-use.

NATURAL FACTORS

Orography

During this research it came out that some of the collected buildings have been built in not very accessible places due to orography reason.

This factor brings with it two considerations: on one hand in case of landslide these architectures could be in high danger and, on the other one, accessibility could really affect the total restoration cost.

The indicator shows the level of difficulties that could be faced in case of restoration works.

Climate

Climate can play a key role in building state of conservation. Even if the range of temperature all over the year is not so wide, both Brazil and India climates bring heavy rain seasons. Depending on regional sub-climate due to the vastness of the two countries there are different condition that can affect the conservation of buildings.

The indicator shows the level of hostile climate that the building is facing.

Vegetation pressure

In some cases, both in Brazil and India, it is possible to highlight how the vegetation around buildings can damage it. With this indicator it has been taken into consideration only the vegetation threatening the integrity of the building, such as big trees or aggressive roots systems able to deteriorate the built structure or even cause the collapse of part of it. Furthermore, as stressed by “Das Canoas house” case study in Rio de Janeiro, highly dense vegetation can also modify the micro-climate and produce material pathologies.

The indicator shows the level of aggressive vegetation around the building.

URBAN FACTORS

Accessibility

The double role played by accessibility factor emerged in several case studies. Sometimes building not very accessible have better preserved their characteristic but at the same time, usually, they are in worse condition than the most accessible ones. In this research accessibility is seen as a good factor for the building preservation.

The indicator shows the level of problem of accessibility expressed by the site.

Urban pressure

Brazil and India are currently facing unprecedented change following the anthropocentrism of socio-economic growth. Massive urban growth in big centres is affecting directly the existing cultural heritage resources throughout the South American and South Asian regions.

If concerns were express for the preservation of important monument and their surroundings (in some cases by the establishment of a buffer zone), very few words have been spent about the urban pressure threatening smallest architecture such as the residential modernist project in this collection.

The indicator shows the level of risk of the building due to urban pressure.

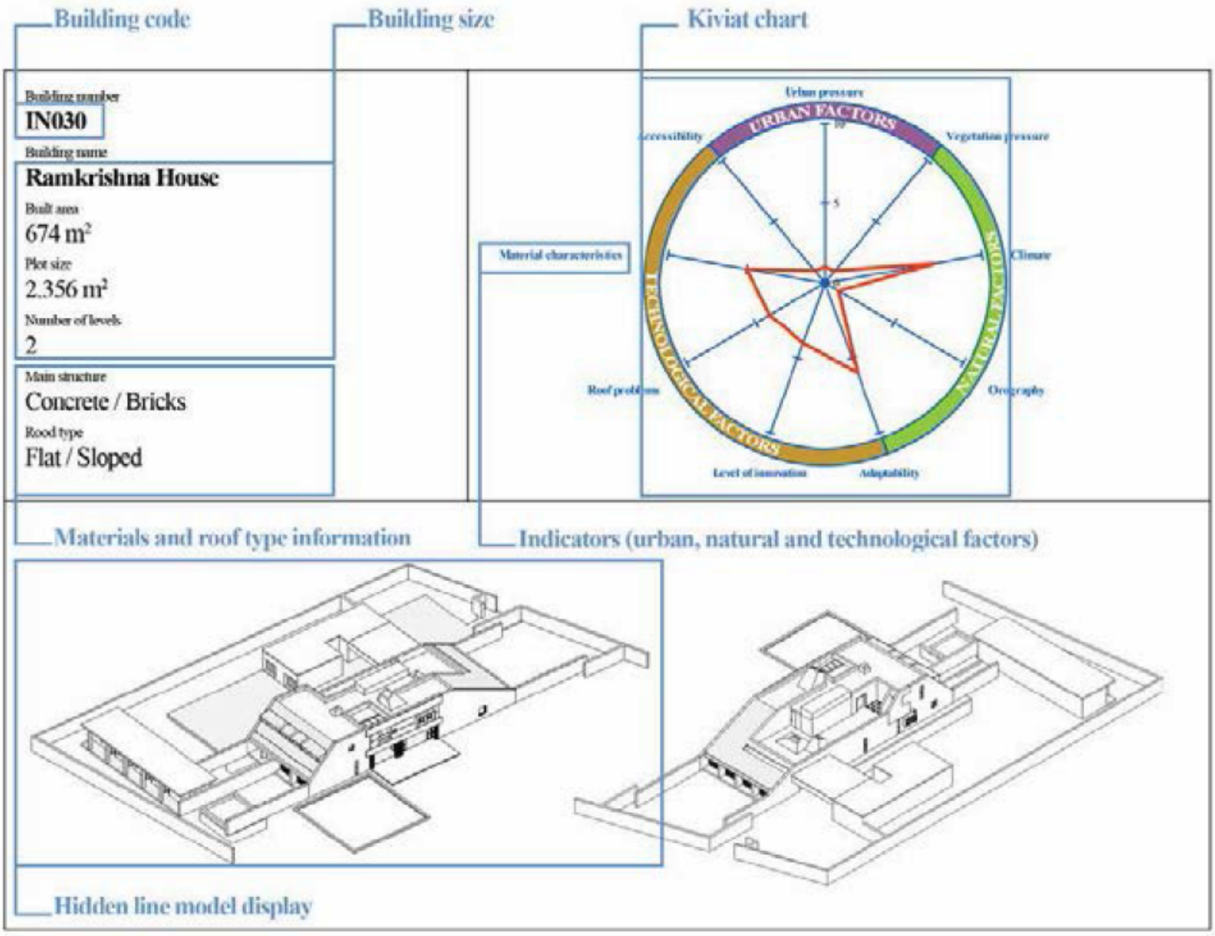
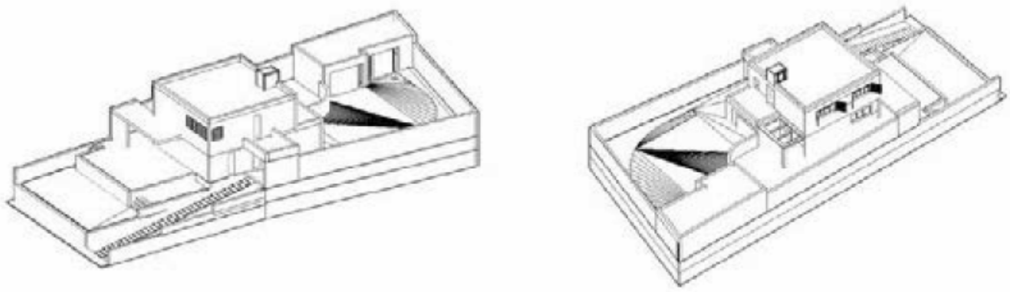


Figure 7.10: information layout for evaluation of the 25 case studies selected (filter 2).

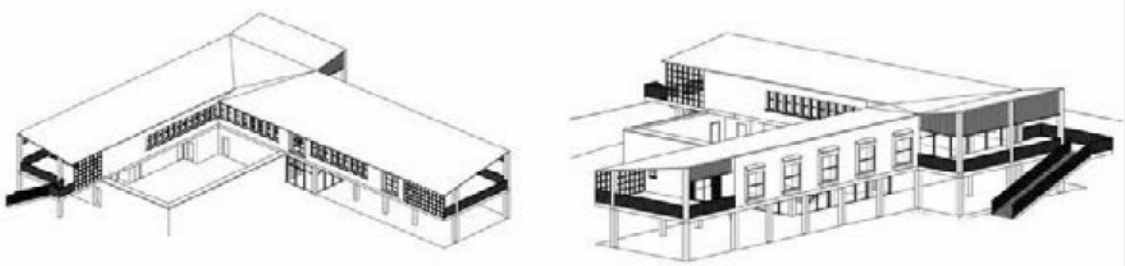
Finally, a couple of images of each model were inserted into the table in order to clarify the building morphology and main architectural features. The chosen layout was the Hidden Line Model Display by Revit software which allow to simply understand the house characteristics and volumes.
This operation has been carried out for each building in order to generate the 25 following tables of contents.

BIM Model of buildings in Brazil

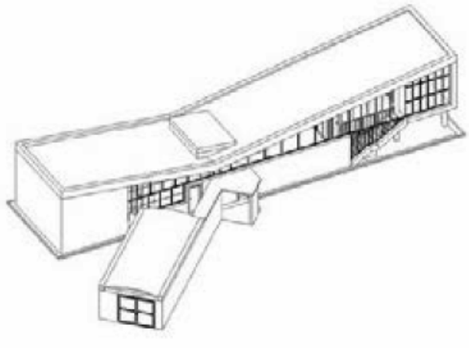
Building number
BR001
Building name
Casa Modernista Rua Itápolis
Built area
252 m²
Plot size
499 m²
Number of levels
2
Main structure
Concrete / Bricks
Rood type
Flat

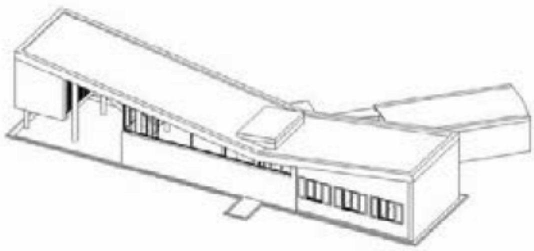


Building number
BR020
Building name
Casa Saavedra
Built area
283 m²
Plot size
n. a.
Number of levels
2
Main structure
Wood / Bricks
Rood type
Sloped

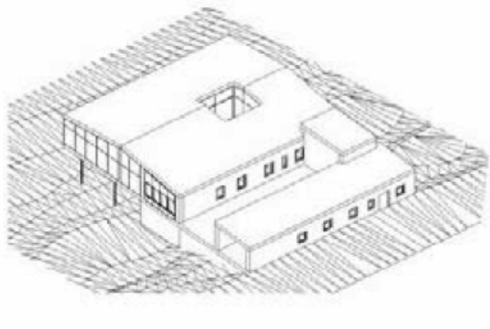


Building number
BR054
Building name
Residência Vilanova Artigas
Built area
252 m²
Plot size
1600 m²
Number of levels
2
Main structure
Concrete / Steel / Bricks
Rood type
Butterfly

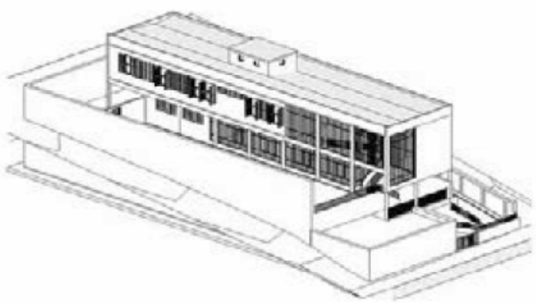


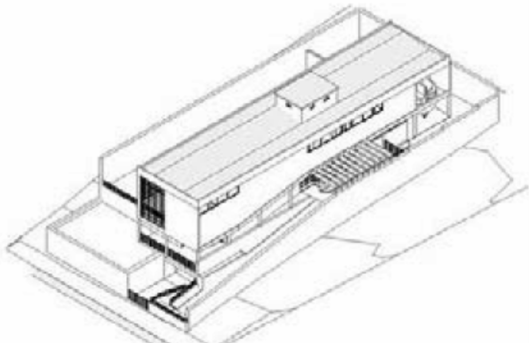


Building number
BR058
Building name
Casa de Vidro
Built area
547 m²
Plot size
9.000 m²
Number of levels
2
Main structure
Concrete / Steel / Bricks
Rood type
Sloped

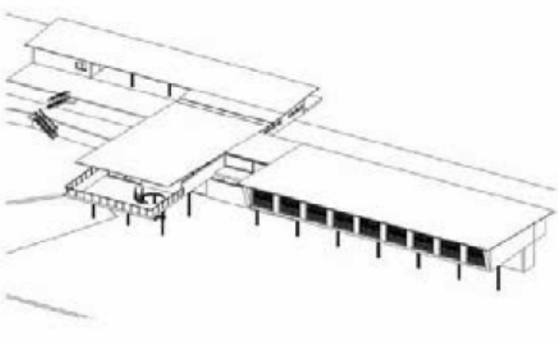


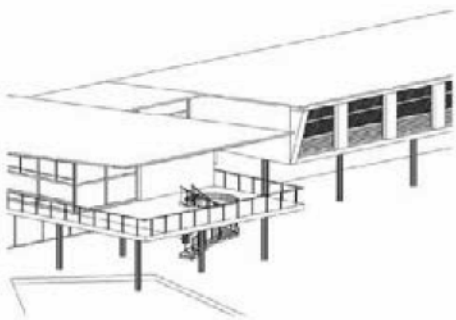
Building number
BR061
Building name
Casa Bettega
Built area
312 m^2
Plot size
864 m^2
Number of levels
3
Main structure
Concrete / Steel / Bricks
Rood type
Semi-sloped





Building number
BR080
Building name
Residência Olivo Gomes
Built area
1.278 m^2
Plot size
n. a.
Number of levels
2
Main structure
Concrete / Steel / Bricks
Rood type
Butterfly





Building number

BR112

Building name

Casa na rua Suécia

Built area

305 m²

Plot size

786 m²

Number of levels

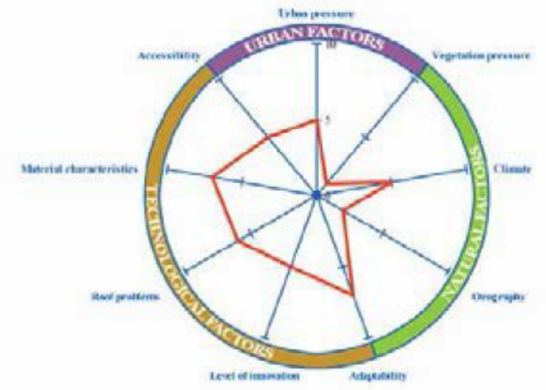
2

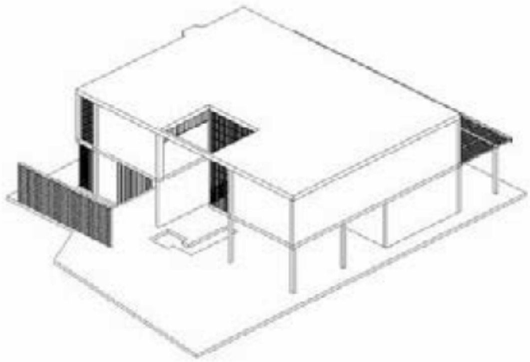
Main structure

Concrete / Bricks / Wood

Rood type

Flat





Building number

BR122

Building name

Residência Antonio Mauricio da Rocha

Built area

420 m²

Plot size

960 m²

Number of levels

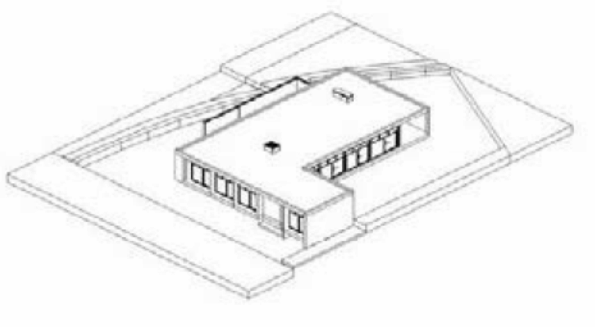
1

Main structure

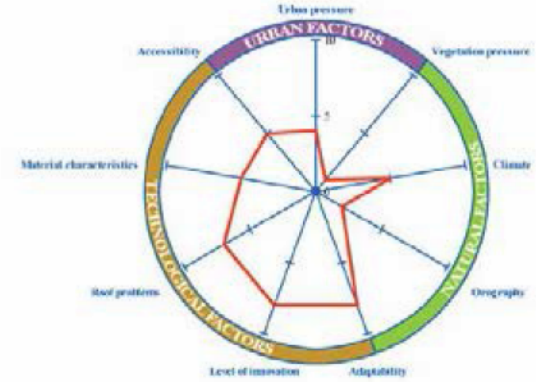
Concrete / Bricks

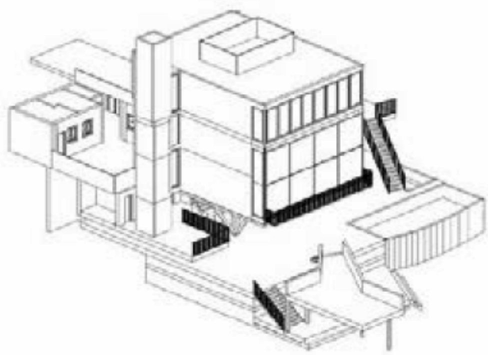
Rood type

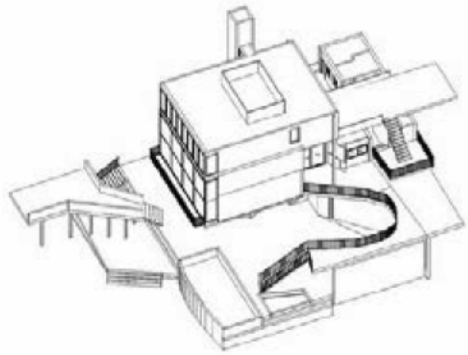
Flat



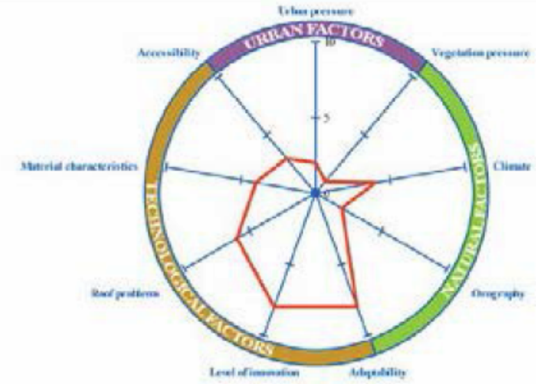
Building number
BR129
Building name
Residência Cunha Lima
Built area
407 m²
Plot size
759 m²
Number of levels
4
Main structure
Concrete / Bricks
Rood type
Flat

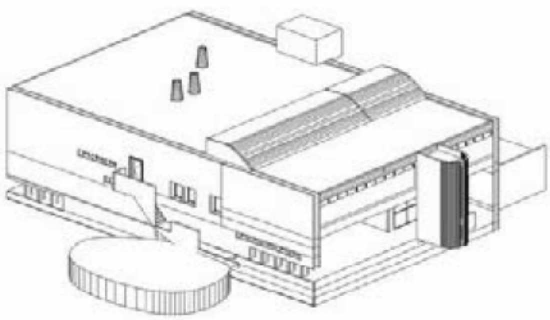


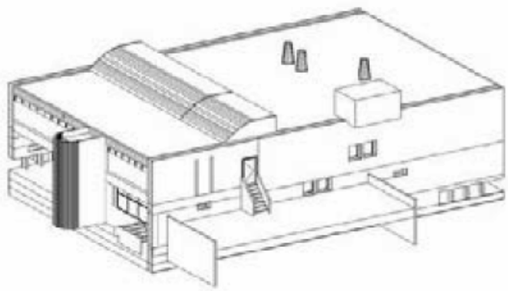




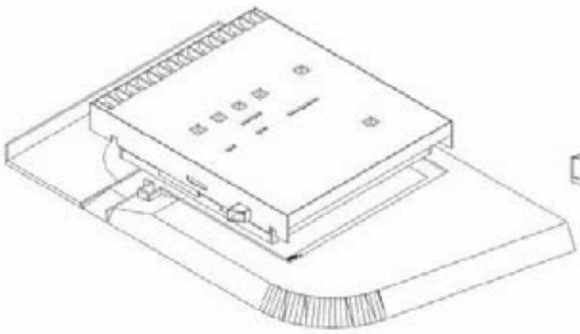
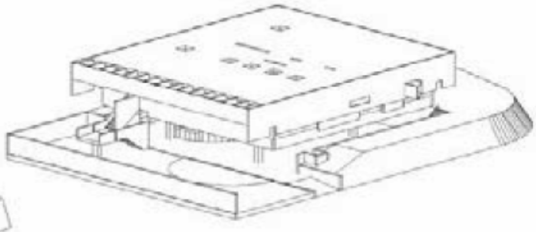
Building number
BR138
Building name
Casa Celso Silveira Mello
Built area
440 m²
Plot size
2.474 m²
Number of levels
2
Main structure
Concrete
Rood type
Flat



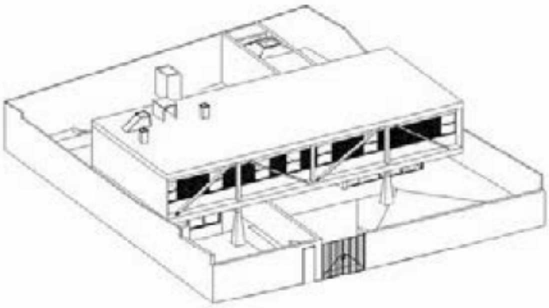
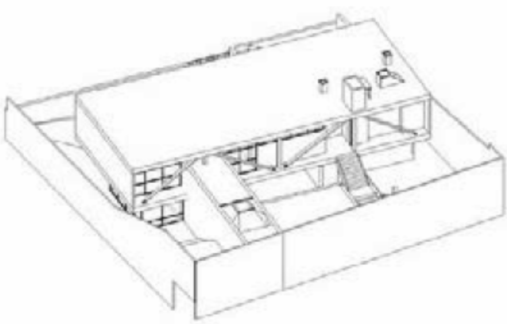




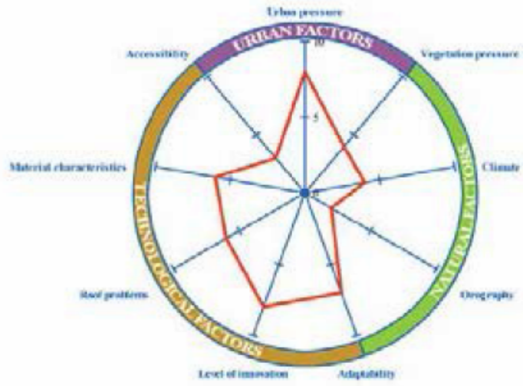
Building number
BR156
Building name
Residência Paulo Mendes da Rocha
Built area
440 m²
Plot size
2.474 m²
Number of levels
2
Main structure
Concrete
Rood type
Flat

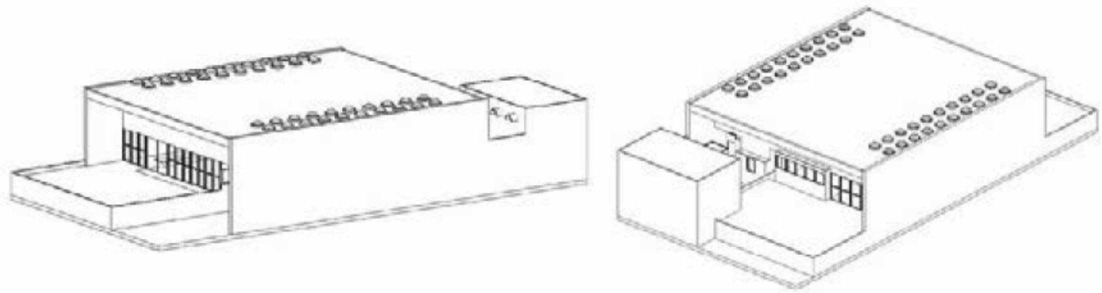



Building number
BR167
Building name
Casa Mendes André
Built area
276 m²
Plot size
506 m²
Number of levels
2
Main structure
Concrete / Steel
Rood type
Flat

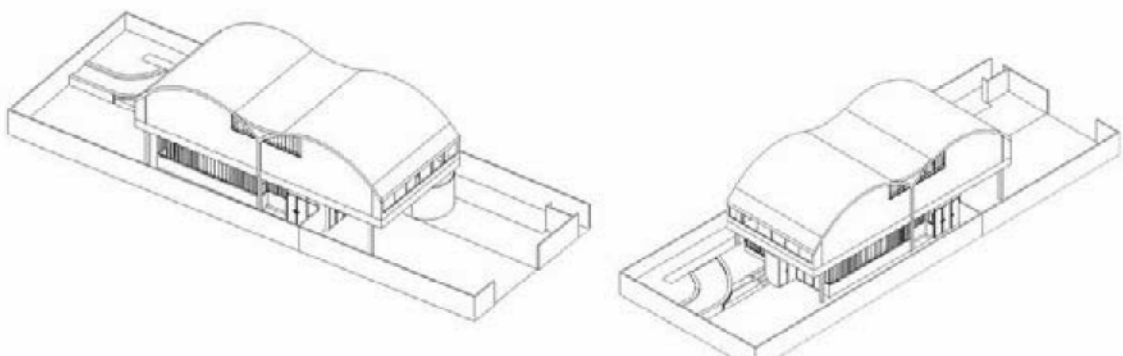



Building number
BR170
Building name
Residência Telmo Porto
Built area
575 m²
Plot size
630 m²
Number of levels
2
Main structure
Concrete
Rood type
Flat

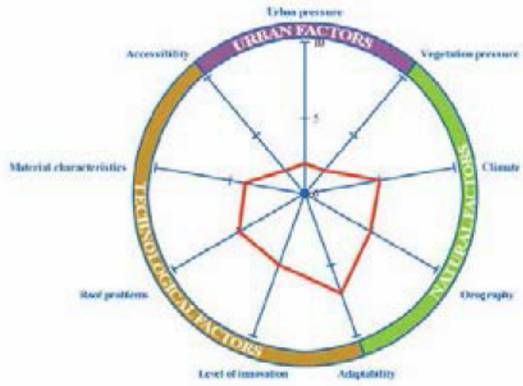


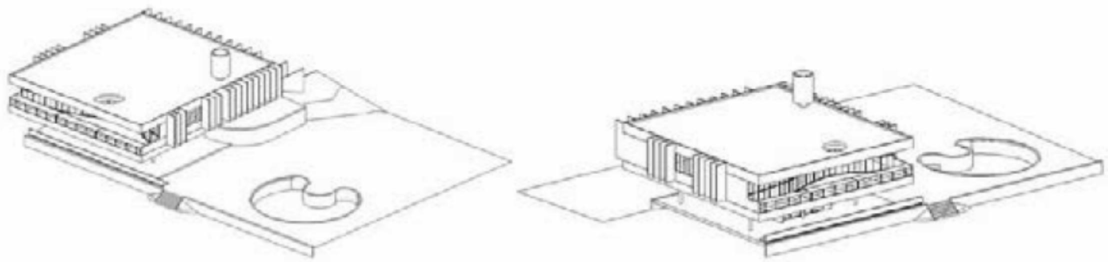


Building number
BR171
Building name
Residência Juarez Brandão Lopes
Built area
277 m²
Plot size
435 m²
Number of levels
2
Main structure
Concrete / Bricks
Rood type
Voult

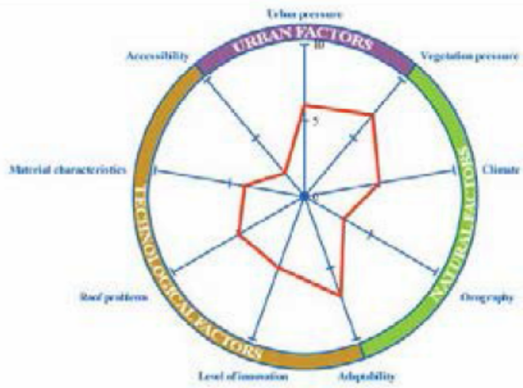


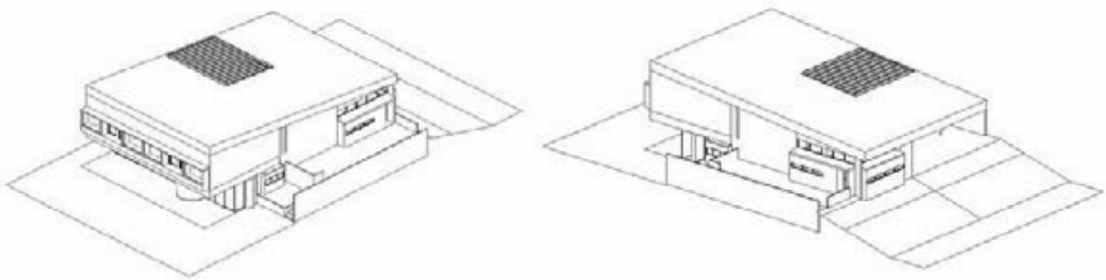
Building number
BR180
Building name
Residência Nadir Zacarias
Built area
530 m²
Plot size
1.890 m²
Number of levels
2
Main structure
Concrete
Rood type
Flat



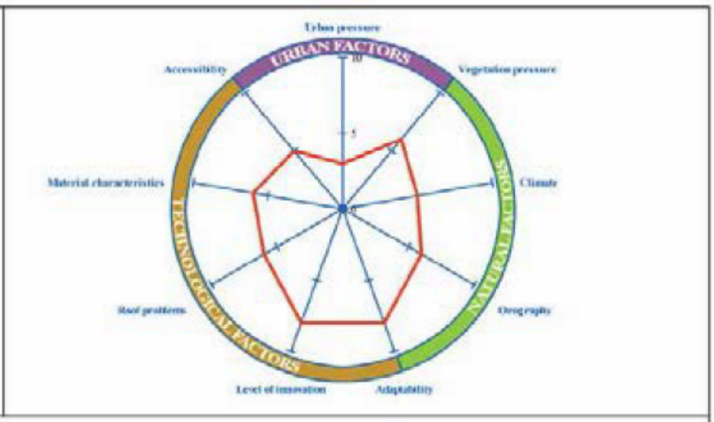


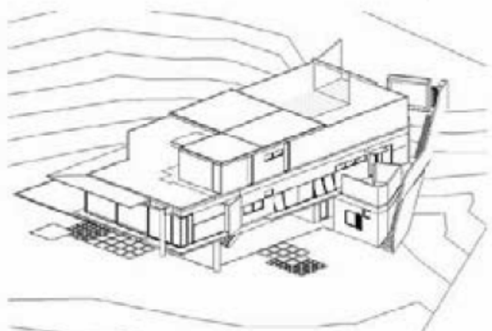
Building number
BR182
Building name
Residência Paulo Bastos
Built area
325 m²
Plot size
1.100 m²
Number of levels
2
Main structure
Concrete
Rood type
Flat

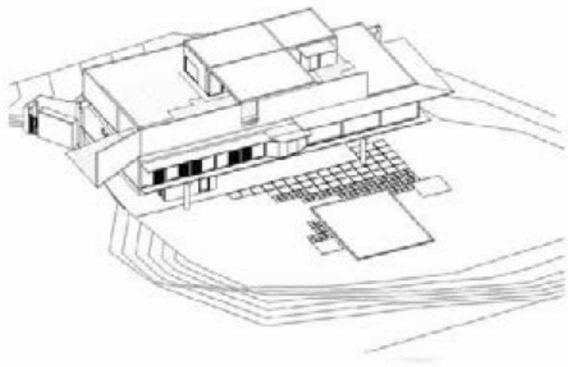




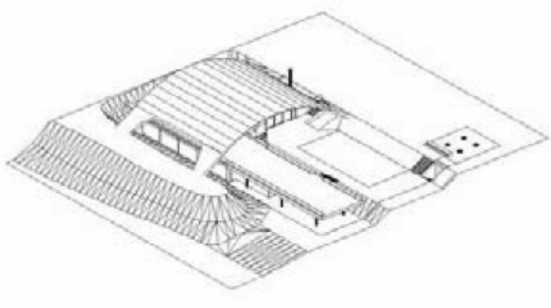
Building number
BR183
Building name
Residência Liliana Guedes
Built area
416 m²
Plot size
2.000 m²
Number of levels
3
Main structure
Concrete
Rood type
Flat

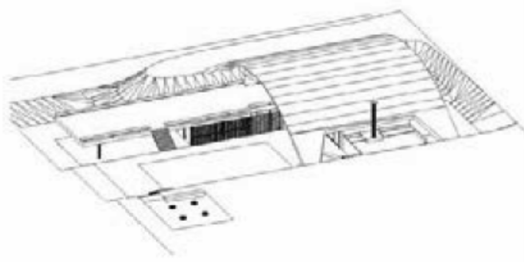




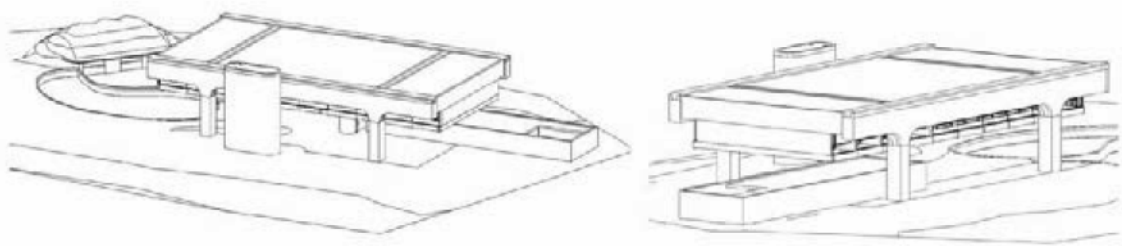


Building number
BR189
Building name
Residência Milan
Built area
392 m²
Plot size
2.150 m²
Number of levels
2
Main structure
Concrete / Stone
Rood type
Vault

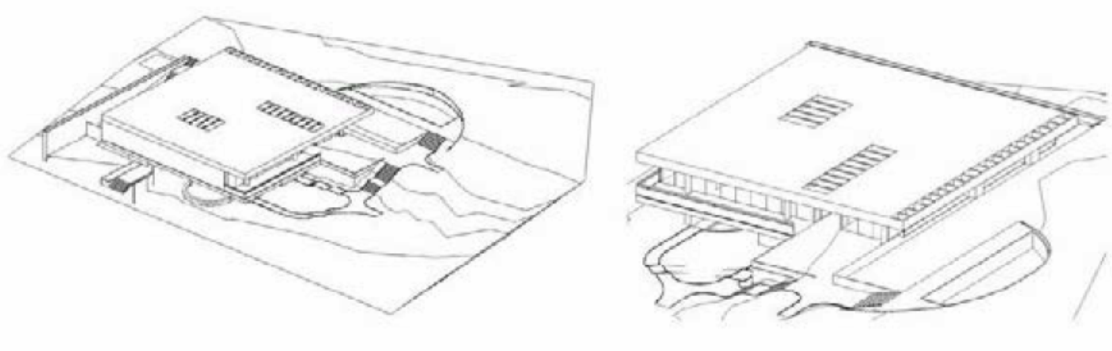




Building number
BR191
Building name
Residência José da Silva Netto
Built area
837 m^2
Plot size
n. a.
Number of levels
2
Main structure
Concrete
Rood type
Flat

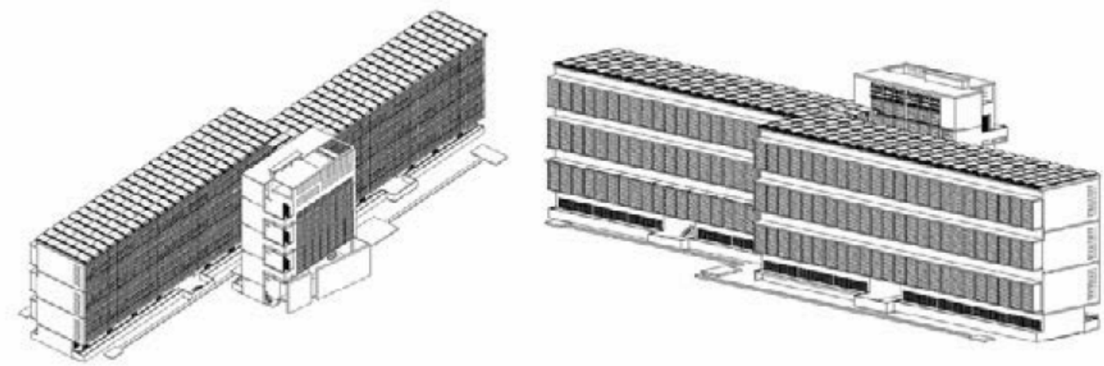


Building number
BR199
Building name
Residência Max Define
Built area
741 m^2
Plot size
3.770 m^2
Number of levels
2
Main structure
Concrete
Rood type
Flat

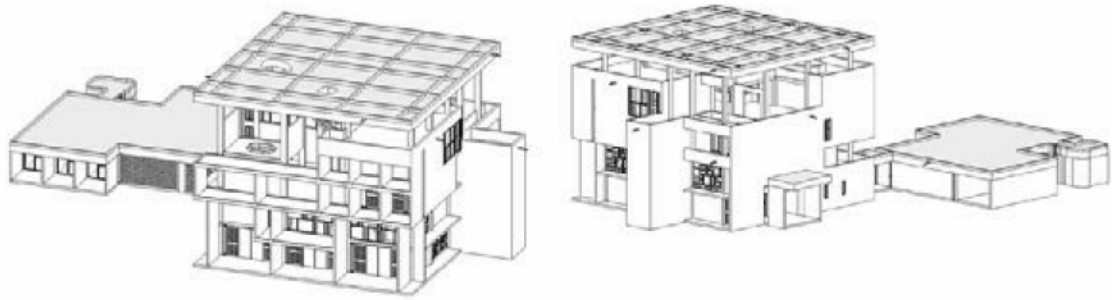


BIM Model of buildings in India

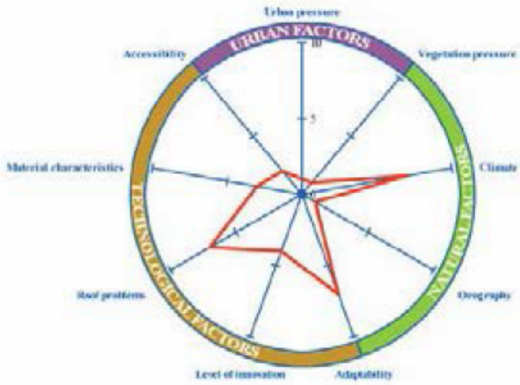
Building number
IN001
Building name
Golconde Housing
Built area
2.068 m²
Plot size
2.497 m²
Number of levels
5
Main structure
Concrete
Rood type
Flat / Vault

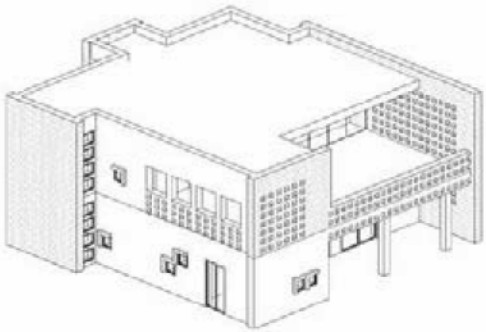


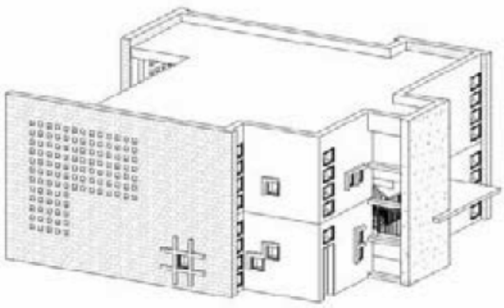
Building number
IN005
Building name
Shodhan House
Built area
1.880 m²
Plot size
7.840 m²
Number of levels
5
Main structure
Concrete
Rood type
Flat



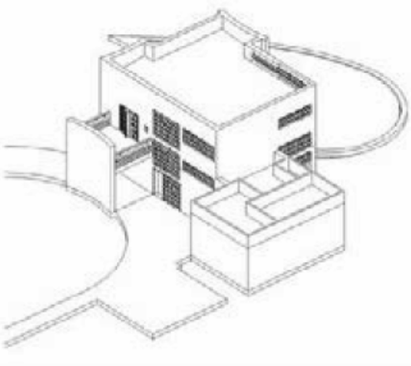
Building number
IN007
Building name
House Type 5J
Built area
433 m²
Plot size
n. a.
Number of levels
2
Main structure
Concrete / Bricks
Rood type
Flat

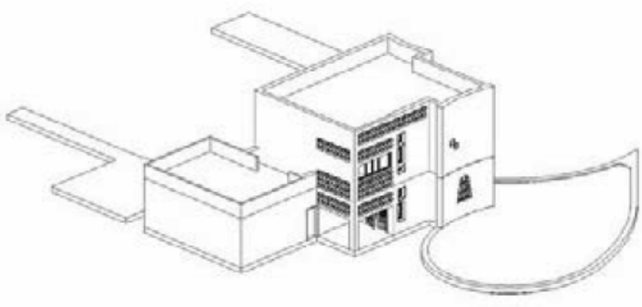




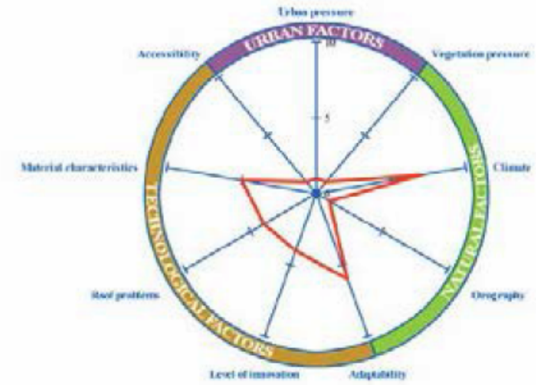


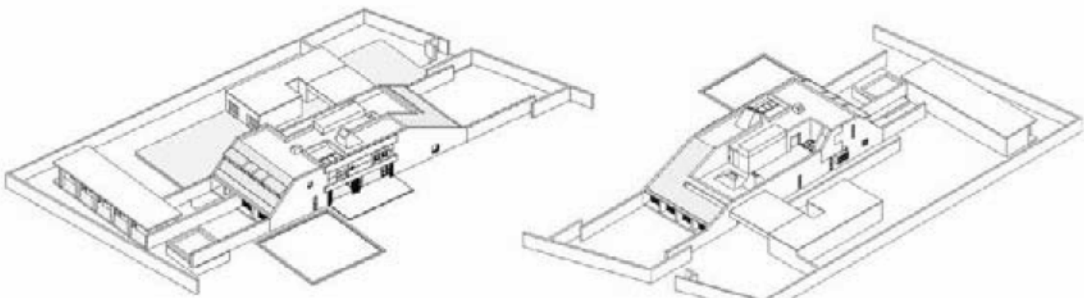
Building number
IN008
Building name
House Type 4J
Built area
243 m²
Plot size
8.350 m²
Number of levels
2
Main structure
Concrete / Bricks
Rood type
Flat





Building number
IN030
Building name
Ramkrishna House
Built area
674 m²
Plot size
2.356 m²
Number of levels
2
Main structure
Concrete / Bricks
Rood type
Flat / Sloped





7.4 Filter 3: 3D survey application. Selection of 3 buildings

The choice of three case studies for the application of this topic arose primarily from the need to cooperate with foreign institutions already partners of the University of Ferrara and with which the partnership was most strong.

In this way, working with the Brazilian University "Escola da Cidade" in São Paulo and with the Oscar Nimeyer foundation in Rio de Janeiro it was decided to start the first test in August 2014 on the Niemeyer's private residence "Casa das Canoas". The result was a complete 3D database of the building and its surrounding environment (Leica C10 has been the equipment used), which was then processed in the laboratory in Ferrara and on which different typological analysis and degradation of materials diagnosis were done.

In December 2015, in partnership with CEPT University a test on the surfaces of a portion of its university campus in Ahmedabad allowed to test a low cost tool like Geomax sps zoom 300 in a context such as India where the funds for protection and restoration of cultural heritage are always very limited.

During 2016, in collaboration with the University of São Paulo and the Getty Foundation of Los Angeles it was identified the FAU USP building case study. The scholarship allocated by the American foundation has allowed the laser scanner survey of external concrete surfaces of the large complex and a considerable improvement of the quality of the information related to the state of global conservation of the building.

Below there is a detailed description of the four analysed cases studies.

FAU USP Building, by João Batista Vilanova Artigas, Sao Paulo, Brazil (1960)

João Batista Vilanova Artigas vision was influenced by Frank Lloyd Wright. His residential projects showed characteristics of Wright Organicist Architecture: space continuity, different levels of floors and roofs, horizontal windows.

His architecture was based on primary geometric forms and the use of reinforced concrete as structure and finishing at the same time. Besides his professional and teaching activities, Artigas also had a very active political life. He participated in the foundation of IAB São Paulo Department (Institute of Brazilian Architects) and worked hardly to promote it between his colleagues as well as to improve Brazilian participation in the UIA (International Union of Architects) congresses. Artigas has had a great importance in the Brazilian Modern Architecture as he helped to establish the basis of the Paulista Brutalistic School[1].

Many architects such as Paulo Mendes da Rocha, Décio Tozzi, Ruy Ohtake were influenced by his projects, his thoughts as well as his actions. In 1985 the UIA recognized his value as an architect granting him the August Perret prize for the application of technology in architecture.

[1] Artigas, V., *Vilanova Artigas*, Brazil, Instituto Lina Bo e P.M. Bardi, 1997

He was among a group of professors that pushed to establish the São Paulo university's architecture faculty. The faculty's building was designed by him with Carlos Cascaldi in 1960.
The Architecture and Urban planning faculty of University of São Paulo (Portuguese: Faculdade de Arquitetura e Urbanismo da Universidade de São Paulo) was inaugurated in 1969 and is considered one of the main representatives of architectural modernism in Brazil.
Characterized by the use of bold and unornamented yet compact forms, exposed concrete construction expressive of its making, and interior spatial complexities, the building is the most emblematic of the Paulista school. The design shows not only architectural and structural interests of Artigas but also his personal ideas regarding the role of modern architecture for society. The building is representative of the third stage of Artigas' production. The work he produced at the beginning of his career is primarily domestic and formally inspired by Frank Lloyd Wright.
The second part of his personal path continues some of his earlier concern with housing but developing an architectural language that would be characteristic of Paulista school.

Figure 7.11: FAU USP building (São Paulo) by João Batista Vilanova Artigas.

This third stage, which begins in the late Fifties, is defined by an interest in large-scale public buildings that are semiautonomous from the city. The exterior of the building is composed of a large reinforced concrete box supported by fourteen tapering columns: in contrast to the plain heavy volume, the lower floors of the building are open and made up of transparent glass-clad volumes. In the interior space, the ground level is where the great open hall is located, cafeteria, museum, and main circulation ramp. This open and top lit space is the centre of the building and is the architectural manifestation of Vilanova[2] interest in political issues.
The FAU USP building is defined to follow a thesis of spatial continuity where the floors are connected by ramps in order to give the feeling of one single plan. This continuous physical interconnection reflects

[2] See: CARRANZA L.E., LARA F.L., *Modern architecture in Latin America,* USA, University of Texas Press, 2014

a commitment to the reevaluation of its curriculum of integrate architecture, urbanism, industrial design and visual communication.

Figure 7.12: Artigas lecturing at FAU USP building (São Paulo).

The basement level with the auditorium and workshops, is sectionally connected to the space via an opening on the ground: Vilanova's vision sees the school as a place to educate citizenry, which happens in the first floor central space, the area with political and social relations, a space of conviviality, of meeting and communication used in this way till now. The second floor houses the offices, studio spaces and the library, while the upper floors are made up of intermediary levels of open studios reinforcing the whole continuity of the architecture.

The space is predominantly open, ambiguously defined, and dramatic through the use of natural light. The exterior columns like other contemporary explorations, read both as tectonic and atectonic by means of tapering profile that changes from square base on the ground to flat surface of the reinforced concrete box. The building besides the formal elements that determine it as an extraordinary example of Paulista school in architecture.

Casa das Canoas, by Oscar Niemeyer, Rio de Janeiro, Brazil (1951)

Oscar Ribeiro de Almeida de Niemeyer Soares was a Brazilian architect (Rio de Janeiro, 15th December 1907 - Rio de Janeiro, 5th December 2012). His personal life and his career were deeply affected by the constant political shifts that Brazil was experiencing in the twentieth century. It can be said that the two factors, which defined Niemeyer's life were architecture and politics. He was keen on the "curve-the liberated sensual curve" that was made possible by new technologies. In 1988, at 81, Niemeyer was awarded the Pritzker Architecture Prize, architecture's most prestigious.

He was still involved in diverse projects at the age of 100, mainly sculptures and adjustments of previous works. Designed by Niemeyer in 1951 as his family home, Das Canoas House is considered one of the most significant examples of modern architecture in Brazil and is well recognized by specialists in art history as a synthesis of modern architecture and authorial self-creation that flourished in Europe and in America.

Figure 7.13: Casa das Canoas (Rio de Janeiro) by Oscar Niemeyer.

The most interesting feature is the fusion of organic architecture and minimalist architecture. Das Canoas puts geometric regularity in crisis, but does not alter the formal purity. From Mies design to Niemeyer's Das Canoas, it is possible to see the evolution of reinforced concrete into a modern building material[3].

Niemeyer chose to build his house in Canoas, Barra da Tujica, which is a residential neighbourhood located in the West Zone of Rio de Janeiro. The architect most likely chose this location, because the West Zone is reasonably quiet, which makes it perfect for a domestic dwelling.

An atmosphere of harmony and piece was created in there and the architect could enjoy the same simple pleasures as in Mendes. Furthermore, he could go back in the days when his wife and he went to the Botanical gardens regularly.

It cannot be denied that the idea about integration between the building and the surroundings was one of the driving forces of the design. It was not just about creating a beautiful setting around the dwelling, the architect wanted to make the house a part of the landscape. This is why Niemeyer modelled the whole building around a large rock that was situated on the site and it was left there as the binding element of the whole project. The upper floor of the house, which was defined by the means of Modernist architecture-glass skin, concrete slab and steel, waved around the rock, incorporating half of it in the interior and leaving the other half to freely flow into the pool outside. This created a strong unity between

[3] See: Weinstraub A., Hess A., *Oscar Niemeyer Casas*, GG, Brazil, Brazil editora, 2012

the outside and the inside, the natural and the artificial. The result was a design that was Modernist in nature but which contradicted Modernism on one of its main points about creating universal and reproducible architecture, which is disconnected from the site. In order to minimize the visual separation between architecture and nature, Niemeyer wrapped the living room in a skin of glass that allowed the interior to blend with the exterior. Another trick was arranging the house according to the terrain. The lower floor is tucked into the existing slope thus creating the feeling that the house is following the contours of the site. This concept is reinforced by the flowing shape of the concrete roof, which blends with the shape of the surrounding hills. This idea originated from the roof of the Dance Hall, which Niemeyer designed in Pampulha. There the structure followed the outlines of the island, on which the building stood. It is almost as if the house is just a passage and not a permanent dwelling.

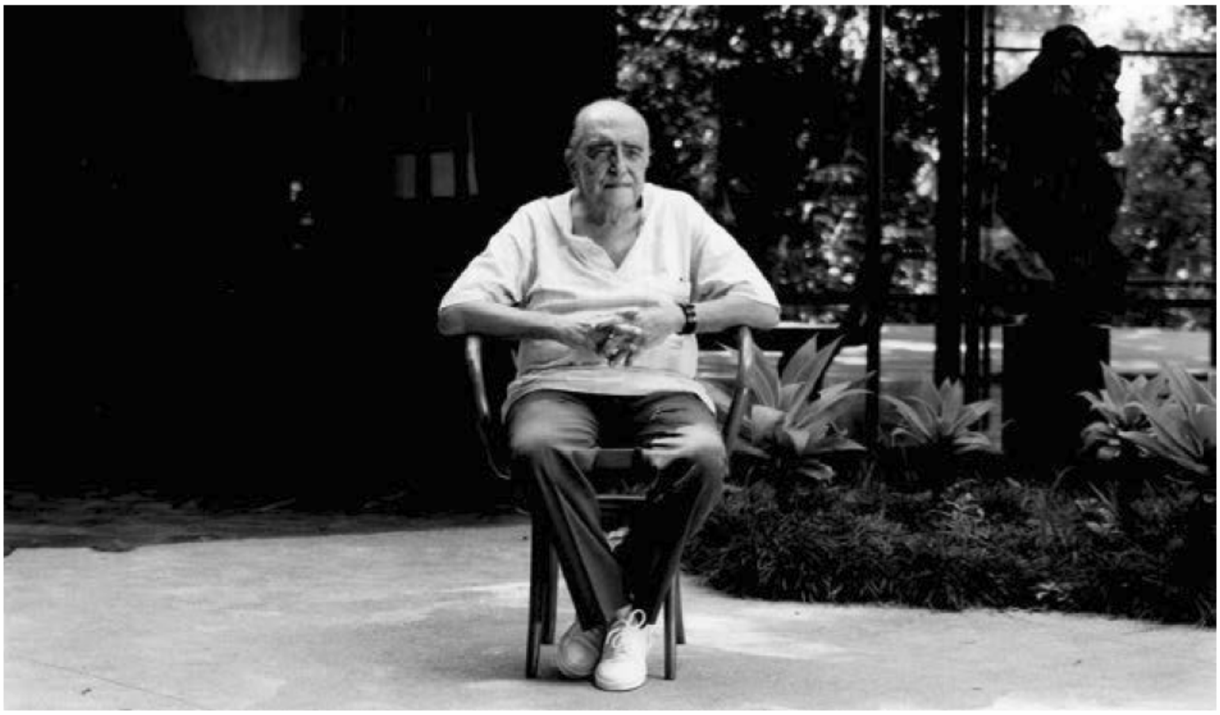


Figure 7.14: Architect Oscar Niemeyer in front of das Canoas house.

There is a kind of axis being formed, which directs people to go through the house and continue their walk out in the open.

The second entrance is on the opposite wall of the first one. It is a sliding door that leads to a cosy corner, defined by a curved wall. The connection between the upper and the lower floor is a staircase, which is carved into the rock, which in turn provides the connection between the interior and the exterior.

The house is currently facing bad problems of materials deterioration and lack of maintenance. Main degradation issues are vegetation, that is growing very fast on external walls and on horizontal surfaces due to the local climate; structural, because part of the house is slowly moving towards the hill slope and an intervention need to be urgently planned; big cracks cross the bedrooms ceiling and rain water is leaking inside the house, plaster is becoming very fast darker and weaker; swimming pool pavement shows cracks and deterioration and further analyses are required to better understand the causes of this problem; great geological instability of the slope subject to strong storms is a serious degradation factor.

CEPT University complex, by Balkrishna V. Doshi, Ahmedabad, India (1972)

Architect Balkrishna Doshi is probably nowadays the last living master of modernis movement in India. After having worked for four years between 1951-54 with Le Corbusier in Paris, Doshi returned to Ahmedabad to supervise Le Corbusier's projects.

Doshi had the chance to work closely with Louis Kahn and Anant Raje, when Kahn designed the campus of the Indian Institute of Management, Ahmedabad.

Figure 7.15: CEPT University complex in Ahmedabad, India, by Balkrishna Doshi.

Apart from his international fame as an architect, Doshi is equally known as an educator and institution builder (founder Director of the School of Architecture, founder Director of the School of Planning and founder Dean of the Centre for Environmental Planning and Technology, all of them in Ahmedabad)[4].

The Centre for Environmental Planning & Technology designed by Doshi during early Seventies in Ahmedabad, has a language of exposed bricks with concrete, emphasizing the slabs and the beams to create a natural texture which has weathered over the years and now almost forms part of the land. The buildings are organized as double floors linear masses, open from both sides, letting in plenty of light and ventilation into the studios. In addition, there are inclined skylights on top of the studios, perpetually letting in natural light into the spaces.

The studio spaces have bay spaces facing the exterior, creating semi-private spaces which are yet totally open to the exterior - spaces where the individual can be alone with nature even in the environment of a studio. The design of the whole complex represent the Doshi search for a regional expression of modernism approach and the hybridization of Luis Kahn lessons taking into account the location of the

[4] See: Melotto B., *Balkrishna Doshi Sangath,* Italy, Maggioli Publisher, 2012

site: a western area of Ahmedabad where hot dusty winds may roll in from the not too distant desert. As highlighted by William J.R. Curtis in *Balkrishna Doshi, an architecture of India* the orientation toward the north light with the exclusion of hot afternoon sun by presenting blank walls to the west was the main concern of Doshi: “He decided to interpret the place as an open space in which the classrooms sense must be all over outside as well inside the building”. In the same direction goes the interesting solution of interlocking terraces that would draw the ground under then up into the building through a sequence of shaded porticos linking inside to outside.

The stepped section helps air flow through the interiors from one side to the other. Seen form the north-west, the low cascade terrace rhymes with grassy hummocks. Underneath there is a solid townscape of brick floors, benches and steps that can be used for lectures and discussions. The idea for Doshi’s school was born in the early 1960s, when the intellectual climate of Ahmedaabd encouraged the planning and growth of a number of educational institutions as NID (with strong inputs from Charles and Ray Eams).

The Doshi’s own office was a training ground and many young Indian architects carried out their apprenticeship there. Some, like Suryakant Bhavasar and Sureh Shah stayed on to become essential member of the design team. Doshi’s vision of architecture was born from the contacts with the great masters Kahn and Le Corbusier and was developed through the quest for an authentic architecture blending old and new, regional and universal, with relevance beyond India.

If other Indian architects were grappling with the problem of how best to modernise yet maintain a core of cultural identity Doshi’s work does not provide recipes for doing this but that the architect must avoid both international and national stereotypes.

The aim should be to transform, not to imitate or to reproduce.

Doshi’s attempt at formulating a modern architecture in an Indian tradition shares certain features with the efforts of contemporaries like Raj Rewal, Charles Correa and Anant Raje. Each in his own way has tried to generate forms that fuse the more durable principle of modern architecture with fundamental lessons from the past. Doshi’s ideas have great relevance for other developing countries undergoing drastic change but also trying to re-incorporate features of their ancient heritage.

It is still too early to gauge how Doshi’s contribution will be absorbed or rejected by younger generation in India but for sure important lessons remain as an inheritance: as stated by Doshi in 1996[5] “Time or style likewise is a limited notion, it can be easily set aside if we realize that all that we are presently perceiving is through our memories of past and present and that there are layers which must be seen together and not as fragmented issues be they of art, architecture or life.

It is therefore essential that we look from distance with eternity or timelessness as the basis so that our solutions could be holistic and during”.

[5] See: Belluardo J., Kazi Khaleed A., *An architecture of Indipendence,* USA, The Architectural League of New York, 1998

Figure 7.16: Balkrishna Doshi teaching at CEPT University complex central courtyard.