

BUILT HERITAGE RESEARCH AND EDUCATION

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Abstract

The University of Beira Interior (UBI) is one of the most recent Portuguese universities (1986). First polytechnic and then university it is structured in five faculties. The existing knowledge fields include engineering, social sciences, humanities, arts and letters, communication and health sciences. The Department of Civil Engineering and Architecture (DECA) is part of the Faculty of Engineering. The main degrees in the DECA-UBI are the Integrated Master degrees in Architecture and in Civil Engineering. These are a five year program which combines undergraduate and postgraduate study into a single course. The interdisciplinarity and interrelation, which link both research and education, are the basis for the production of knowledge at DECA-UBI.

Built heritage is a very important cultural asset as the evidence of any society development and it is a field of interest at DECA-UBI. It refers to all aspects of the man-made environment such as houses, places of worship, commercial and office buildings, monuments and other places of historical significance. Built heritage helps to define a sense of place and identity for communities. It is not only about monuments of exceptional value but also includes small modest vernacular buildings that represent other equally important historical, social and cultural values. The attention paid to the built heritage has increased in Portugal. It should be emphasized that some of these buildings are now used for functions that did not exist when they were built. Furthermore, the actual technical requirements are not always compatible with the former building. A regular maintenance of these buildings may include preservation, rehabilitation, restoration, reconstruction, adaptation and interpretation. Balance needs to be achieved. The future of built heritage conservation is focused on the sustainable built environment. Conservation does not require buildings to be preserved in their original condition to accept contemporary use. It may change over time as community values evolve. However it is important, as a cultural asset, to retain its original heritage features. While heritage conservation is a key player in sustainability planning, interdisciplinary skills that are needed to deliver the heritage studies and projects of the new generation architects which combine aspects of cultural heritage with the best preventive conservation, projects, methodologies and practices. For this purpose, it is important to link with engineering sciences.

In this paper, the authors describe their experience concerning this link between research and education in the Integrated Master degree in Architecture, which is emphasized by the specific and multidisciplinary research performed as members of the faculty staff at DECA-UBI linking with other sciences of engineering as thermal comfort, acoustics and daylighting. A few examples presented are the analysis of the performance of acoustics and daylight of Cistercians churches, the acoustic analysis as a support for the architectural rehabilitation of an outdated theatre, the thermal performance of new housing of an adapted monastery, to perceive the user's satisfaction of a vernacular housing through a post occupancy inquiry, the rehabilitation from vernacular ruins.

Keywords: Architecture, Built Heritage, Research, Education.

1 INTRODUCTION

The University of Beira Interior is one of the most recent Portuguese universities. Since 1986 it has developed multiple education and research centers, now structured in five faculties. One of these faculties is the Faculty of Engineering which incorporates the Department of Civil Engineering and Architecture (DECA-UBI).

The main objectives of DECA-UBI are education, research and providing services in the scientific areas of Civil Engineering, Architecture and Geographical Information Systems. The main degrees in DECA-UBI are the Integrated Master degrees in Architecture and in Civil Engineering [1]. Furthermore, the DECA-UBI provides a doctorate degree in Civil Engineering. The majority of the doctoral faculty staff is integrated in research centers.

The integrated Master in Architecture (300 ECTS credits) is a symbiosis between the 1st cycle and the 2nd cycle. The two cycles comprise a five year program which combines undergraduate and postgraduate study into a single course.

The 1st cycle enables students to obtain a Bachelor's degree in basic sciences in Architecture after completed 6 semesters (180 ECTS). The 2nd cycle, which provides students with a master's degree in Architecture, comprises 3 semesters of curricular units (90 ECTS) and one semester entirely dedicated to the Dissertation/Project (30 ECTS) [2]. The curricular unit Dissertation/Project (30 ECTS) can be practical (Architectural Project) or theoretical (Dissertation).

The interdisciplinarity and interrelation, which link both research and education, are the basis for the production of knowledge at DECA-UBI. Among the different research themes, a particular attention is devoted to the built heritage in Portugal, and its connection with the engineering sciences as thermal comfort, acoustics and daylighting.

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The future of built heritage conservation is focused on the sustainable built environment. Conservation does not require buildings to be preserved in their original condition to accept contemporary use. It may change over time as community values evolve. However it is important, as a cultural asset, to retain its original heritage features.

While heritage conservation is a key player in sustainability planning, interdisciplinary skills that are needed to deliver the heritage studies and projects of the new generation architects which combine aspects of cultural heritage with the best preventive conservation, projects, methodologies and practices. For this purpose it is important to link with engineering sciences.

2 METHODOLOGY

In this paper, the authors describe their experience concerning this link between research and education in the Integrated Master degree in Architecture, which is emphasized by the specific and multidisciplinary research performed as members of the faculty staff at DECA-UBI linking with other sciences of engineering as thermal comfort, acoustics and daylighting [3], [4].

A few examples presented are the analysis of the performance of acoustics [5], [6], [7] and daylight of Cistercians churches [8], [9], the acoustic analysis as a support for the architectural rehabilitation of an outdated theatre [10], the thermal performance of new housing of an adapted monastery [11], [12] to perceive the user's satisfaction of a vernacular housing through a post occupancy inquiry [13], the rehabilitation from vernacular ruins [14], [15], [16].

The authors' research lines are analyzed, with particular incidence in the Architectures of Cîteaux in Portugal [17], and its heritage legacy, connected with the engineering sciences such as the thermal comfort [11], [12] acoustics [5], [6] and the natural light [8], [9]. Interdisciplinarity and connection are the lever for the scientific knowledge production [1], [3], [4], [18].

The research projects are also a way of connecting education and research as it is considered an important output thematic dissertations. The authors describe their multidisciplinary experience concerning the ORFEUS Project (EXPL/EPH-PAT/2253/2013) - The Tridentine Reform and music in the cloistral silence: The Monastery of S. Bento de Cástris [3], [4], [17].

3 RESULTS

The Dissertations/Projects associated with the ORFEUS project express the importance and contributions of Cistercian architecture in contemporary religious architecture [18], the morphology of the Cistercian churches as well as the relationship between the architecture and music [7] always with the Church of the Monastery of S. Bento de Castris as an element of study.

The aim of the DECA's research is to provide the ORFEUS team with information on the actual acoustics of this space and attempt to establish knowledge regarding the architecture of the Church of the Monastery of S. Bento de Cástris as well as the duality of its choirs [4]. Acoustic comfort levels must be guaranteed in all usable spaces in order to optimize the transmission of sounds and listening conditions which are essential for all audience members; therefore, such studies should be continued [5].

In this sense, alongside the work that has been developed, two integrated master's theses in Architecture (2013/14) were prepared under, the ORFEUS Project [3], [4]. Thus, this work is divided into importance and contributions of Cistercian Architecture in contemporary religious architecture, the morphology of the Cistercian churches, the relationship between architecture and music, having always as a case study the Monastery of S. Bento de Cástris where the timeliness and relevance of the topic is demonstrated.

3.1 Built heritage research in Cistercian context

The Cistercian Monasteries were located out of any urban settlement. However, in time, many of these constructions were integrated in a contemporary ever growing urban space which changed drastically its boundary conditions.

The Cistercian monks from Alcobaça left the Monastery in 1833, one year before the extinction of the Religious Orders in Portugal. This extinction was possible by a law of 28 May 1834, and had the intention to secularize ecclesiastical possessions.

Due to the architectural legacy of these historical buildings and the economic stimulation that moves public and private attention towards some kind of rehabilitation, there is an incentive to undergo multidisciplinary studies in order to understand these monastic buildings. Modern life also requires new standards of living, which can be applied to the heritage buildings [4], [5], [17]. Some questions may arise to the contemporary way of life in order to reuse these impressive constructions.

The Portuguese Cistercian heritage research at the Department of Civil Engineering and Architecture of the University of Beira Interior began in 2008 and since then students of the Architecture Integrated Master's Degree are invited to research about Cistercian Architecture. This research is reflected at this UBI Department always regarding the Portuguese Cistercian Heritage and also its divulgation to society (either by articles or papers and symposia organization) [4].

The research on the Cistercian legacy conducted at DECA-UBI was developed in connection with two other research centers - Lab2PT (Landscape, Heritage and Territory Laboratory) and CIDEHUS (Interdisciplinary Centre for History, Culture and Societies) - is an innovative multidisciplinary study.

Consequently, the results achieved in the research of the Cistercian legacy in Portugal have many different approaches: the former monasteries and their architecture are the main subject concerning morphology, architectonic rehabilitation but also acoustics, thermal comfort, or natural light [4], [5]. This research culminated in the FCT Project ORFEUS (EXPL/EPH-PAT/2253/2013).

3.1.1 The ORFEUS Project

The ORFEUS Project (EXPL/EPH-PAT/2253/2013) - The Tridentine Reform and music in the cloistral silence: The Monastery of S. Bento de Cástris – was financed by the Foundation for Science and Technology (FCT) with community co-financing through the COMPETE program “Programa Operacional Factores de Competitividade” (Operational Program Factors of Competitiveness), of QREN and the European Union (FEDER) [4].

The University of Évora was the proponent institution through the Interdisciplinary Centre of History, Cultures and Societies (CIDEHUS), and the University of Beira Interior was one of the partner institutions together with the University of Minho and the University of the Azores.

The ORFEUS Project is based on a multidisciplinary approach around the Tridentine Reform reflexes in the musical Cistercian feminine matrix between the 16th and 18th centuries [4].

To know the particularity of S. Bento de Cástris an analysis of a selection of its legacy was required [19], taking into account previous studies, and a comparative perspective (especially with the monasteries of the same Order, the same historical time and with different female Orders) and reflection upon the occupied spaces, to play or sing, in monastic structures which also moved in the considered chronological framework. In this research there was a solid connection between different,

but interconnected, fields of knowledge as history, heritage and music to which was later added the acoustics and natural light

This research, guaranteed by historians, architects, engineers, musicologists made it possible to achieve the proposed results and accomplished much more than the initially previewed results, with a significant International dimension [4].

Following this research line at UBI, stimulated by the ORFEUS Project, research on Cistercian architecture is further analyzed, making it possible to reach conclusions through the interrelation of the various examples of Cistercian monasteries in Portugal [3], [4], [19].

Two master dissertations in architecture (2013-14) were achieved within the ORFEUS Project [7],[18]. These works and research demonstrates the actuality of the theme as well as the importance and contributions of Cistercian Architecture in contemporary religious architecture, the morphology of the Cistercian churches [18], the relationship between architecture and music [7] as well as the importance of natural light.

The existence of the entire database of the project which is accessible online at <http://orfeus.pt> is noteworthy as well as a CD with recordings “in loco” of the musical legacy at Monastery of S. Bento de Cástris as being the main ‘outputs’ of the ORFEUS the Project [3].

3.1.2 Research developed by DECA-UBI under ORFEUS project: a contextualization

The inclusion of the University of Beira Interior in the ORFEUS Project follows the active participation of this institution in the organization of two scientific events which enhanced its participation in the submission of the candidature ORFEUS Project - “The Tridentine Reform and music in the cloistral silence: the Monastery of S. Bento de Cástris” to FCT.

These scientific events were: “1st International Symposium Cistercian Spaces: Architecture and Memory” (2012 / March / 8-9), at the University of Beira Interior, and “Cistercian Residence of S. Bento de Cástris” (2013 / September / 19-21) at the Monastery of S. Bento de Cástris.

This partnership deepened at the meeting, “Exchanging Views on Cultural Heritage” of CIDEHUS (University of Évora), with the analysis of Cîteaux in the scope of the scientific production of CIDEHUS. Also in June, the same partnership generated the organization of a session on “International Medieval Congress 2014 - Leeds” with the support of “Cîteaux: Commentarii cistercienses” having been moderated by Terryl N. Kinder, the editor in chief of this journal.

In 2014, already under Project ORFEUS, the organization of two scientific events and the participation in the scientific commission of a third event stands out. These events were the reaffirmation and continuation of the International Symposium Cistercian spaces and Cistercian Residence of S. Bento Cástris, where the former is dedicated to architecture and music, and the latter to Aesthetics, Space and Time - Counter-Reformation Reflexes in musical praxis.

Noteworthy is also the disclosure of ORFEUS Project as part of the Documentary Exhibition “Cistercian Spaces” which took place at “Núcleo da Real Fábrica de Panos do Museu dos Lanifícios” (UBI, Covilhã).

It was also in 2014, at the University of Beira Interior, that two Master thesis’ dissertations were developed and publicly presented, in the scientific field of Architecture (integrated cycle of studies) [7], [18] in the scope of the ORFEUS project.

Based on these dissertations and the fact that the church of the Monastery of S. Bento de Cástris presents an unusual configuration type of spaces; an acoustic test of the church had to be carried out, exploring its acoustic conditions as well as the study of the acoustic behavior in the Church of S. Bento de Cástris. This phase of the work was only possible to achieve with the support of equipment provided by “Laboratório de Saúde na Edificação” Laboratory of Health in Buildings (LABSED) of UBImedical which enabled articles and joint communications.

As a continuation of this work, a study on natural light in the Church of S. Bento de Cástris and 3D modeling of the S. Bento de Cástris Monastery was developed, as well as its encircling walls.

In early 2015, as a result of that multidisciplinary work, the project was divulged in the Italian publisher ABEditore “Proceedings ICNMC 2015, 1st International Conference on New Music Concepts.” entitled “Cistercian Monastery of S. Bento de Cástris, Évora, Portugal: Acoustic measurements under ORFEUS Project” [5].

In March 2015, the interest generated by the ORFEUS Project, allowed its presentation at “Seminar on Continuous Training: Sevilla, Conventual City - urban and architectural heritage, inside the class of experience of Seville University” at the invitation of the University of Seville.

Although the project has reached its completion time, it continues to promote research associated to other projects [3]. In this sense, the organization of the III, IV and V Cistercian Residences of S. Bento de Cástris, in September 2015, 2016 and 2017 are the main consequences of this continue research.

3.1.3 Acoustics in Built Cistercian Heritage

As members of the faculty staff of DECA this research on acoustics in built Cistercian heritage was to provide the ORFEUS team with information on the actual acoustics of the Monastery of S. Bento de Cástris and attempt to establish knowledge regarding the architecture of its monastic church of as well as the duality of its choirs.

The Church of the Monastery of S. Bento de Cástris in Évora (13th - 19th centuries) presents an unusual space setting which seems to favor different positions for coral groups supporting liturgical and musical expression activities. These options are possibly of an empirical nature, since the scientific knowledge in the field of building physics and in particular of building acoustics are relatively recent.

It was important to explore, with on-site measurements, the actual conditions of acoustic behavior and in particular meet the reverberation time. Consequently, results obtained were compared with the current recommendation for this type of space.

The interest in measuring reverberation time, in this type of enclosed space, was also discussed. Such results of reverberation time measurements were presented and analyzed for the different spaces of the Church.

Finally, the findings of the study presented some hypotheses for future work in terms of acoustic analysis of Cistercian spaces and for a better understanding of the architecture and music relationship, in its different expressions. Acoustic comfort levels must be guaranteed in all usable spaces in order to optimize the transmission of sounds and listening conditions which are essential for all audience members; therefore, such studies should be continued [4], [5], [6], [7].

3.1.4 Natural light in the Cistercian Churches

Some of the Cistercian monasteries denote the importance given to the light in its own title: Clairvaux, Vauclair, Clairmarais [17]. Natural light in the Cistercian churches is closely linked not only with the liturgical requirements at the “officium” but also with the canonical hours based on the “ora et labora” dictated by the Rule of St. Benedict [8].

Time is cyclical, as is the Cistercian cloister life, following summer and winter as well as the play of light and shadow that gives value to the monastic architectural space, making it perfect for a contemplative experience following the Rule of St. Benedict [8].

As the light in the Cistercian Monasteries, mainly, in their churches, is mostly related to the fulfilment of liturgical needs, this research analyses the relationship between daylight conditions within the monastic choirs located within the monastic church [8]. The chant was a very important way of oration thus of the liturgy.

The Cistercian architecture, in its beginnings (12th century forward) is characterized by austerity, simplicity and the play of light and shadow that gives value to the monastic architectural space itself, making it perfect for a contemplative experience. In the Cistercian Monastery the church is the central piece of the monastic building. Nave, transept and apse are the main architectural components to which is added the choir [8], [9].

The essence of daylight is analyzed within the Church of the Monastery of S. Bento de Cástris, in Évora, Portugal [9]. This former Monastery includes the church, at the southeastern corner which has not only a high choir, but also a low lateral choir (within the presbytery). Its unchanged exterior walls are made of solid masonry. Although the function of the walls is primarily structural, the windows allow the daylight to penetrate the space of the church. The combined orientation effect of the church’s main axis and the sun trajectory determines how the sunlight reaches the interior of this architectural structure [9].

This study presents the qualitative and quantitative analysis of the luminous environment in the church of S. Bento de Cástris, being the first based on the authors' perception of the effect of the daylight within the different areas of the enclosed space. The appreciation of the spatial experiences was supported by quantitative daylight simulations that were conducted in selected areas within the space. With this study is intended to contribute to the debate about the specificity of daylight, in the context of Cistercian architecture [9] and describe the objectives and methodology applied to the case study, through the evaluation of the behavior of natural light by simulation in virtual models of the church.

Firstly, the church was designed in the Sketchup tool. Secondly, the drawing was imported to the simulation tool, where the optical characteristics were set up as well the coordinates of the place (Évora, Portugal). Simulations were carried out where the level of the illuminance was obtained [9].

In order to verify the performance of the natural lighting in the building under study, the environment is simulated through the VELUX Daylight Visualizer. As much information and detail as possible that were collected, were essential to obtain the elements as drawn, such as plants, sections and elevations images, which dimensions were confirmed "in situ" as well the covering materials were registered, with different colors and shapes [9].

The survey of all the materials present in the space was indispensable to be able to use in the three-dimensional model as closest to reality as possible. The method for obtaining the reflectance and transmittance value of opaque and transparent surfaces were described. In order to obtain these values, two portable lux meter devices that measure the levels of illuminance, through a light sensor that has a capture light on 180° amplitude. For all opaque surfaces inside the room, an illuminance measurement was carried out with one sensor in the direction opposite the surface and the other in the direction of the surface. The quotient between these two values corresponds to the reflectance of this material. A second measurement was carried out on the inside of the glazing towards the outside, about 1 cm away from the glass and also on the outside of the glazing towards the outside. Again, the quotient between the illuminances results in the transmittance of the glass [9].

3.1.5 Retrofitting and thermal comfort in Built Cistercian Heritage

The Monastery of Our Lady of Nazaré of Mocambo in Lisbon is an exciting study case. First of all, it became part of the city of Lisbon, being completely absorbed by the urban expansion. Finally, this building was subject to a major rehabilitation being an example of multiple and successive adaptations.

The former cells are now adequate and modernized apartments for today's comfort needs. The local thermal comfort of these dwellings was studied under the weather of Lisbon [12]. An exposed heavy wall is significantly warmer during the winter time and provides a significant cooling in summer, when compared to a small lighter window. Moreover, windows may allow overheating especially on facades facing the sun [11].

Thermal mass is most effective through reducing temperature swings, expecting to keep thermal comfort during the entire year. It was established that the interior surface temperatures, in heating period, decreases more slowly on walls than on windows. During the cooling period, the thermal resistance of a wall also allows for reduced heat to flow from the outdoor environment into the building [11].

3.2 Built heritage research in vernacular context

Passive strategies have been used around the world for centuries. In the last decades, we became dependent on mechanical systems, with rising economic and environmental impacts. It is therefore important to learn from the past to understand how houses evolved to respond to the surrounding environment.

The analysis of the local vernacular dwellings provide insight into well adapted popular solutions to deal with the local climatic conditions in promoting responsive passive building technologies which usually are not found in the literature.

However, significant gaps exist in the data and understanding of building stocks' composition as most methods to address existing buildings are derived from new construction [20]. Sustainable buildings aim to be adapted to local social-economic, cultural and environmental contexts. It should include all factors that may affect the natural environment or human health, having in mind the consequences for future generations [21]. The demand for sustainable buildings with minimal environmental impacts is

increasing, leading the construction industry to adopt new technologies for building design [22], [13], [14], [15].

3.2.1 Vernacular housing

Vernacular building traditions are repeatedly cited in the academic literature as exemplary models of environmental practice. However, studies that explicitly examine these kinds of vernacular housing in Madeira Island and its inhabitants are unknown. Therefore, research that addresses the vernacular traditions of the Madeira Island may emphasize its potential for continuity and viability for maintenance and rehabilitation. Madeira's Housing is an important expression of the action of man over nature, making emerge a harmonious landscape between the built and its surroundings [15].

In response to the accentuated topography, terraced platforms appeared to soften this inclination. Here the vernacular building revealed itself as a wise design, where the masters of the craft create a communion between the space, utility, comfort and the volumetric balance, emerging a new artificial element that connects with the natural space [15].

This study analyses the vernacular heritage housing built anonymously in Madeira Island, Portugal, which is a very specific type of vernacular heritage: once its primary function was of shelter, then housing and nowadays new uses are being implemented.

The low value given to this anonymous popular architecture, in comparison with other representative architecture, could connect a broad understanding of the diversity of new uses in former vernacular buildings and how it can be strengthened in the future regarding a sustainability approach in the practice of architectural design [15].

This study was the first part of a larger research that seeks to set a debate about this form of vernacular housing that includes such relevant issues as immaterial and cultural traditions. The approach was initially based on a survey of 66 houses, with almost a century, through a systematic analysis. So that this contextualization to be possible, it's necessary to proceed to the identification of the local geography, the socio-cultural and climate keywords of the region which provided the existence of these houses, as well as its integration, its transformation and its permanence in the territory and above all the identification of the elements which make this housing unique.

3.2.2 To perceive the user's satisfaction of a vernacular housing through a post occupancy inquiry

This research analyses through inquiries whether a very specific type of vernacular heritage housing in Madeira Island, Portugal provides comfort.

A total of 13 recent questionnaire responses from the initially based survey of 66 houses, with almost a century, were analyzed to understand the residents' satisfaction with existing conditions through post-occupancy evaluation [13], [14], [15].

Several variables were associated with the dwelling and thermal comfort. It reports that the inhabitants have been able to achieve some degree of thermally comfortable conditions for much of the year.

The results of this research provide valuable information for future housing sustainable rehabilitation. This may also enable the Local Authority, to identify ways of improving the quality of life for residents [13], [14], [15].

3.2.3 The rehabilitation from vernacular ruins vs. bioclimatic architecture

This research is the basis for a reflection about implementation of bioclimatic concepts in the architectural Project. Thus a bioclimatic approach to concepts and their application on a retrofitting project in the region of Covilhã (Portugal) achieving building harmonization with the environmental characteristics of the project site [16].

Bioclimatic architecture reveals itself as an essential tool for the architectural project as a way to ensure comfort with low energy consumption, according to local climate and site surroundings.

It is essential that the student, as future architect, realizes how to reduce the environmental impact of interventions, strategies, reuse, reducing energy consumption with the use of the buildings and learn best practices and thermal processes in reusing built heritage.

So this study was part of an initial solution, hypothetically, designed to address possible concerns of environmental comfort, confronting it later with some variations, changing some constructive systems and/or materials, thus incorporating a new reality of bioclimatic concepts through passive design [16].

3.3 Built heritage research: architecture and acoustics

In a time and context in which the rehabilitation of the historical centers of the towns is an increasingly discussed topic, architecture assumes a central role. There is a tendency that populations of the historical centers are becoming no longer permanent residents. This is the reality of urban life and consequent degradation of built heritage. Consequently it is imperative its preservation so that the actual and future society may appreciate it.

On the past, all over the country numerous theatres were built and some of them are now abandoned or degraded, needing urgently an intervention. This type of built heritage can become once again the cultural center of small towns. In this context, a multidisciplinary team, involving architecture and engineering, was set up to support the decision leading to the development of a proposal for rehabilitation of a much degraded building, the old movie theater in Chaves town (Portugal). The proposal was developed within the scope of a master's Project of an architectural student [10].

Throughout the architectural retrofitting proposal it was always considered the materiality of the building. As a result of this idea, the light and acoustics were the major premises of organization and choice of materials for each area promoting a special interconnection between every part of the building [10].

A special attention was given to the auditorium due to the acoustic behavior. The technical support was essential for the decision making, either for the architectural design and formalism, or for the choice of the most appropriate materials. It involves different types of drawings in architectural practice that must integrate various aesthetic, functional, technical, artistic, economical requirements which are achieved through form, dimension, or combination of parts, as well as its volume [10].

In the study of the concert hall, the requirements established in the Portuguese regulation for auditoriums, concert halls and cinemas were observed. The regulations allow for some reduction of the minimum requirements in terms of sound insulation of buildings in the process of rehabilitation located in historical zones, in order to make feasible the adoption of constructive solutions that confer patrimonial and historical identity. Although there is some flexibility for acoustic insulation rates for air and impact sounds, the regulation states that the acoustic conditioning project for these spaces should include a specific study to ensure an adequate reverberation characteristic in a wide spectrum of frequencies and to good Intelligibility of sound in the various places of the room.

The acoustic conditioning project of this concert hall, with a complex geometric configuration, includes a specific study to ensure acoustic conformation adequate to its functional use. The study of geometric acoustics and reverberation time was particularly important. The analysis carried out was reflected in the options undertaken by the student, both in the adequacy of the architectural design of the interior of the concert hall, or in the selection of finishing materials.

4 CONCLUSIONS

Through this specific research at UBI, encouraged by the ORFEUS Project, the research within the Cistercian Heritage, as a system, allows to reach conclusions through the interrelation of various examples of Cistercian monasteries in Portugal. Through this research a sense of cultural awareness is revealed to students of Architecture providing a very specific formation.

It should be noted that the monastic architecture is a research niche, comprehensive and transversal which in Portugal, with regard to research in architecture and engineering, begins to take its first steps.

The Built heritage, either Cistercian or vernacular, shows a great respect for existing environment and represent unique examples towards sustainable building design.

In fact, this research aims to provide to architectural students a very aware and complete formation. Consequently, the different aspects of vernacular heritage rehabilitation can be a factor of cultural growth or development and how such transformation may be achieved is learned and improved, contributing for the knowledge about this particular type of housing.

The results of this research provide valuable information for future housing sustainable rehabilitation as well as an important contribution in the improvement of an architecture that achieves and integrates the bioclimatic principles and respect its surroundings, both physically and environmentally.

This knowledge is transmissible not only through scientific articles, but also through the outputs of project research as it is the case of the project ORFEUS. Ultimately, built heritage research and education are deeply linked to multidisciplinary research performed and provide a distinctive framework in the Dissertation/Project of the Integrated Master in Architecture linking Architecture with other sciences of Engineering.

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