

## 684: From the Modern *toit jardins* to the current green roofs: can a hit become classic?

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### Abstract

What do builders think regarding the use of vegetation on roofs? The present paper looks for an answer in Brazil, a country where the technology still does not show an expressive development, even in the city known as its “ecological capital”, Curitiba. It should be stressed that the technology of using vegetation on roofs carries the impressions of at least two moments in the History of Architecture: first, the ancient use in the hanging gardens of Babylon and the turf houses from Island; and second, their dissemination in the early 20th Century within the Modern Movement in Architecture with Le Corbusier’s *toit jardin* (besides free plans, free facades, *pilotis* and *fenetre-en-longueur*, one of the five points in his Architecture). But nowadays, in the so-called green roofs - name adopted in the Northern Hemisphere – a mature technology can be recognized. Its long evolution is well-known: several implementation problems could be overcome, due to the efforts of a still growing industry particularly in Germany, Canada and the USA. In addition, several factors contribute to a renewed interest for that choice: one should mention high land prices in cities, soil insulation and its effects, and urban heat islands; as well, the pledge for a reduction in energy consumption of buildings and the lack of urban green areas. Nevertheless, the dissemination of such a design strategy seems as difficult a task as it was its technological development. Whereas successful examples become numerous in different parts of the world, there are few green roofs in Brazil, and the situation is not better in Curitiba, despite its positive planning background. It is true that roof greening will develop preferences according to the climatic, physical, cultural and legal constraints. However, the lack of such an adaptation becomes the main research problem here. This paper analyzes those dissemination barriers and the relationship of the civil construction practitioners with the design and construction of green roofs. Their perception, their practices, abilities and familiarity with the subject was investigated by means of a web survey sent to companies in the branches of Architecture, Civil Construction, Agriculture and Forestry, all in Curitiba and Region. The survey’s results are compared with those of some existing green roofs in order to identify the dissemination barriers, contributing to a better capacity building on the subject. Thus, the present paper aims at providing the designers and builders elements for reshaping the city’s architectural identity.

### 1. Introduction

In Brazil, the vegetation use in coverings is known as green roof as well as suspended garden, terrace, roof or ceiling green or alive; ecological, vegetated or greened cover. In this article, the employed term to include all those denominations is green roof (GR).

### 2. Retrospective

Historically the green roofs are known in several regions in the world, as well as the efficiency of thermal insulation of the joint action of soil and vegetation, helping to retain heat inside the building in cold climates and prevent their penetration in hot climates (PECK, 1999).

Although there are no accurate records of its appearance, evidence of gardens on terraces are found since the ancient civilizations that flourished in the valleys of Tigre and Euphrates rivers, according to Osmundson (1999, p. 112). The origin of contemporary green roofs, however, is in Iceland, where they gradually spread throughout Scandinavia, reaching then the rest of Europe and from there, the prairies of North America Colonial, in the nineteenth century.

In the twentieth century, the Modernist movement in architecture was decisive for the spread of the

idea, when Le Corbusier in 1923 includes the *toit-jardin* within five points of the New Architecture. In the years 1970, the urban environmental movement started in Germany helped to occupy the roofs as a way to return the green to the cities, leading this country to carry the movement of GRs after decades of research and development. The pressing environmental issues led much of the German government, followed by Switzerland, Austria, Canada and USA, among others to address problems of cities working on several fronts, not only in urban scale, but also in the buildings. Mainly because of its positive environmental impact, the technique of GRs linked to urban planning is broadcast at the end of the twentieth century in the North, and green building has become a matter environmentally important (ROHRBACH, 2004).

Several factors are bringing staff to the use of vegetation on slabs: the urban conformation, with cost and scarcity of land, soil sealing and the islands of urban heat, the financial and environmental imperatives of reducing the energy consumption of buildings, and lack of urban green areas, among others. The examples multiply by the world, but are not very present in the Brazilian reality, although historical examples can be cited in Rio de Janeiro (MEC, 1936-1945;

Museum of Modern Art - 1948). Examples of isolated green roofs gradually gaining prominence in the media associated with the issue of sustainability, and to conduct heat and energy efficiency of buildings. Moreover, the increasing cost and scarcity of land have led to recreating the natural landscape on artificial media and making the structural slabs with vegetation increasingly frequent in Brazilian cities and misuse of the technical evidence is presented through the pathologies in the structures. Increasingly being incorporated into new projects in architecture, the Brazilian GRs maintain tenuous ties with the original *toit jardin* intention or thermal protection for environments that are covering. Although a past linked to movements pioneers in urban planning and environment, Curitiba, capital of Parana's state in southern Brazil, is no exception.

### 3. Survey - GR in Curitiba

A preliminary survey, with an unspecified number of professionals in Architecture and Engineering working in the Metropolitan Region of Curitiba (MRC), revealed significant ignorance on GRs. Much of the interlocutors were categorical in denying the existence of them in the city of Curitiba, perhaps in the state of Parana, despite the examples that were already showing. In Curitiba's financial centre - in Av Mal. Deodoro and surroundings - notable buildings of banks bearing green roofs on their marquees and terraces and many residential buildings have lawns and gardens on the underground parking. Buildings of the Municipal Prefecture of Curitiba and also from Sao Jose dos Pinhais and Araucária, in MRC, are organically equipped with GRs. Cisterns company's state of water (SANEPAR) in Curitiba are historical examples of thermal insulation use of GRs. These preliminary findings contributed to the direction of this work, in the form of an initial exploration of the capacity of awareness and penetration of new technologies in the universe of professionals in Architecture, Engineering and alike of MRC, based in the Catalogue of Business CREA-PR. For both, were planned and executed a research of opinion (survey) and the identification of Curitiba's GRs examples. Particularly significant is the pioneering nature of this work, which assumed the burden of proving the existence of GRs and discusses its benefits and problems in the context of MRC, through indirect interaction with the community technical potentially involved with the matter.

### 4. Implementation

The survey was the tool used by questionnaire administered via e-mail. The aim was to the collection of information that lead to standardized design of the profile of those involved in designing and implementation of GRs. The approach was chosen with the aim of providing a wide coverage of the universe searched to identify: the profile of the professional potentially involved in the design and implementation of GRs; degree of closeness

with the matter on the part of professionals in construction; training today these professionals, technical problems relating to the implementation of GRs; cultural component associated with the acceptance / rejection of the alternative of coverage; cost-benefit associated with GRs, and possible regional peculiarities. The survey of information via e-survey was completed in a second stage, with the identification and survey of examples in MRC, aiming to identify practices constructive and professionals involved in its implementation as well as problems arising from the use of this option of coverage of slabs. The e-survey was presented to interview by an invitation via e-mail, which included, given that advocates Preece (2002), necessary clarifications, the guarantee of confidentiality regarding personal data and use the data only for academic purposes, and the means of contact with the author and her supervisor. The issues that hypothetically influence the popularization of GRs were structured in accordance with the following standard approach: issues closed, half-closed issues, identification of images and open questions (for examples, criticism and suggestions), a total of 42 items divided in five groups of issues.

## 5. Analysis of results

### 5.1 Group 1: Profile of respondents

This step investigated on five issues, the gender, educational level, the degree of upgrade training (through the date of completion of the final course), the profession and also the areas of professional performance of the respondents. As the Business Catalogue of CREA-PR congregate only firms was not possible to compare the gender of this set with the entire population studied.

Genre: Considering the proportionality between the totals of the CREA-PR professionals and the result of research, the research had a more effective participation of female professionals.

Representing 25% of the population of professionals of Architecture, Civil Engineering, Agronomic and Forestry of MRC, the females had a stake of 46% in the search result. Proportionally, the result shows more receptivity of professionals in Architecture and Engineering to search and the topic addressed.

Considering the low representation of forest engineers and agronomists in the return of search and given the principle of Pareto (RAMOS, 2007), which gives most problems - usually 80% - a small number of causes - usually 20% - (Figure 1), it was decided to consider only the responses of architects and civil engineers (232 respondents), more directly involved with the matter investigated (Fig. 1).

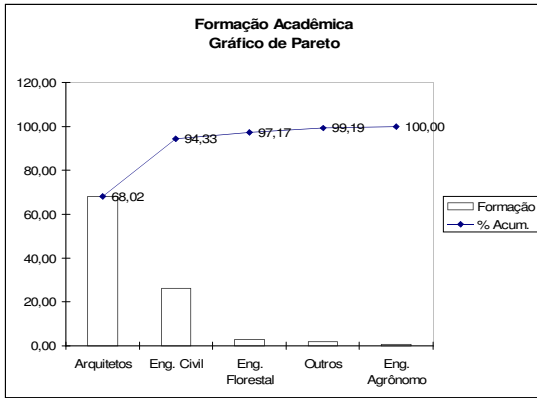


Fig. 1. Pareto's Graphic – Survey's Professionals

Education degree: Over 50% of the sample investigated not advanced in the qualification of the top level, whichever graduation as only the level of basic training. With expertise, only 35.8% of professionals investigated. At the other extreme, master's and doctoral have the lowest rates, not reaching 3% of respondents (Fig. 2).

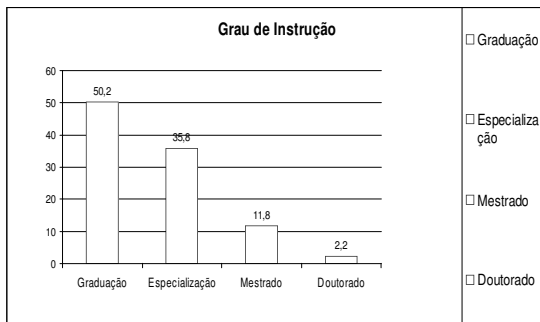


Fig. 2. Instruction Degree

Professional update: Figure 3 illustrates the low number of respondents formed between 1986 and 2005. The downwards trend points to the period when the country faced the so-called "stagflation," or economic growth without inflation, during the decade of 1980 in Brazil, known as "the lost decade" (HENRIQUES, 2008).

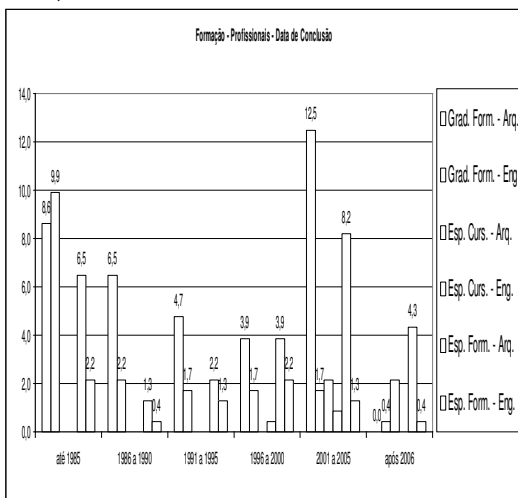


Fig. 3. Professional Update

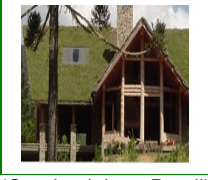


A chance for the shortage of professionals in this period is the change of professional activity. Although the search has only investigated the degree of formal upgrade of professionals, not considering upgrading courses for a small duration, symposia and equivalent, it is clear that distance is significant portion of academia.

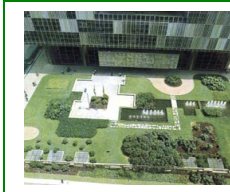

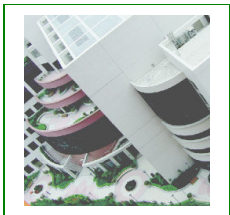
### 5.2 Evaluation of the professional knowledge on the subject.

Two approaches were employed:  
 1) Identification of the name associated with GRs on the professional area of the interviewee.

A profusion of words incorporating the term "garden" to roofs, slabs, covertures and tilings totaling 45% of responses and research found that, despite the predominance of "green roofs" in response, we must consider whether the influence of the name of search leading by inertia possible professional's responses.  
 2) visual identification of various types of GRs, with degree of familiarity and experience of the interviewee (Table 1).

Table 1 – Green Roofs Types - Results

| GR's Type   | Results  |
|---|--|
| Fig.5a - Grassy on inclined coverage<br><br>(Condominium, Brazil) | - 80% denies familiarity and experience with this type of GR;<br>- more than 25% of respondents know this kind of GR<br>Result consistent, since this is certainly the rarest in Brazil.   |
| Fig.5b – Grassy on flat slab<br><br>(Ford Factory, EUA)           | - 50% of respondents indicated professional experience with this type that is not common in Brazil, especially in industrial installations;<br>-about 18% of respondents know.<br>Result conflicting with reality; points to an error of interpretation of the image, the wording of the question or even error in the answer. |
| Fig.5c – Jardinieres on flat slab<br><br>(Coverage – Taiwan)      | - Over 70% of positive values for the knowledge and experience with this alternative that, historically, is perhaps the most common in Brazilian roofs buildings.  |

|   |  |
|---|--|
| <p>Fig.5d - Gardens on coverage of underground parking</p>  <p>(Petrobras' Headquarters - Brazil)</p>                        | <ul style="list-style-type: none"> <li>- 77% confirm the familiarity with these GR - consistent with reality</li> <li>- Curitiba: this type of VC in buildings not only in garages in basements, garages but also in high</li> <li>- Professional experience: 64% accused in the usual mode</li> </ul> |
| <p>Fig.5e - Gardens on flat coverage</p>  <p>(Residential building - based on trade and services – Curitiba)</p>             | <ul style="list-style-type: none"> <li>- 72% claim to know</li> <li>- 31% criticizes the lack of professional experience with this type of GR (found in most of the Curitiba's buildings - of - see Av. Visco Guarapuava, Av. September Seven, Pe. Anchieta Street, for example).</li> </ul>           |
| <p>Fig.5f - Flowerbeds on terraces, balconies and decks in common use</p>  <p>(Princess Margareth Hospital - Hong Kong)</p> | <ul style="list-style-type: none"> <li>- 93% claim to know</li> <li>- 86% of positive responses for work experience</li> <li>- 10% of respondents pointed to lack of professional experience with this type of GR, present in large part of Curitiba's building.</li> </ul>                            |

### 5.3 Group 3: Experience with the theme

1 - Status of project, professionals (architects, civil, agronomists and forestry engineers, landscapers and executors) and supervision of implementation.

Predominate the lack of positioning for professionals and the draft GRs, reaching values expressive on the qualification of project (33%), supervision (37%), architects (45%), engineers (34%) and hand - work (38%). Already the engineers received the highest scores positive (54%), compared with 38% of architects. These issues deserve some considerations:

- According to information collected between professionals of Curitiba, is unusual that the detailing of the landscaping is considered in the design phase of architecture. It occurs to the professionals running the landscaping fit the restrictions of space and structure, and to find solutions to their projects in a previously defined without their opinion.

- The labour which performs steps concerning the GR, such as sealing, trim and regularization of slabs no exception to the reality of Brazilian civil construction. They are abundant examples of diseases in slab (with or without vegetation) due to failures in implementation. Meanwhile the

qualification of the labour force has the permission of 54% of the interviewees, as well as supervising the implementation of GRs (51%), showing that the results are well accepted by professionals surveyed, despite the problems identified in all the examples raised in MRC.

- Second, the agronomists engineers (73%) and forestry (76%) had the highest rates of qualification as opposed to landscapers (29%), with the lowest. Clearly it is a lesser value to the performance of professional landscape, although both agronomists and engineers act as the forest landscape for GRs in the city of Curitiba.

2 - Experience with the theme: receptivity of designers and implementers, availability of materials and techniques in the Brazilian market, the need for structural reinforcement, the relationship and the appropriate types of sealing and the effect landscape.

The study seeks to assess the receptiveness of the environment of the construction industry in relation to the occurrence of a GR. The landscaping, perhaps the greatest attribute of aesthetic appeal of GRs, was the most item rejected by almost 85% of the investigated, while contradictorily the issues that address the receptiveness to the project and the implementation of GRs have obtained approval rates of above 50%. There concepts about the GRs that were also barriers to its spread in the last century, such as belief in the need of structural reinforcement (57%), as identified by Ingleby (2002) to study in the case of London. The item "sealing" is the most debatable. On the one hand, 61% of respondents say the incompatibility between and vegetation and sealing, but 53% agree that this is affected by vegetation. The sealing rigid with 61% approval, is identified as the appropriate system for the GR, a fact that is categorically denied by the authors of manuals and waterproofing (PIRONDI, 1988, pp. 26/27; CUNHA and NEUMANN, 2007). Moreover, 48% of professionals also pointed to sealing flexible as the alternative to correct the GRs, showing the degree of misinformation of the respondents. This is evidenced by the assertive about the need for systems "sophisticated" for sealing with the concurrence of 33% of professionals. The term "sophisticated" was used purposely to confirm the hypothesis of ignorance of the waterproofing system suited to GRs. Issues relating to sealing clearly indicate the need for clarification and qualification from professionals accustomed the subject of GRs. Another key issue is to assess if there is availability of materials and techniques in the Brazilian market and respondents are divided with the agreement (30%), uncertainty (27%) and disagreement (33%), showing that this is an item asking for more clarification from the community of professionals.

3 - The customer perception of the professional According to the professionals of Architecture and Engineering, the issues that relate to the attention of the art, the role seductive and the cost of GRs are crucial for the acceptance of the customer, with rates above 50% in the three issues.

#### **5.4 Group 4: Knowledge about the extent of environmental GRs.**

This set of issues checked the depth of knowledge of professionals for GRs. The answers recorded certain contradictions with previous results. Just like the rejection to the positive aspect of the landscaping on slabs of concrete, the increase in area and the recovery of the property according to the VC are items that divided the opinions of respondents, with almost 50% of agreement on the 40% who disapprove. The item concerning the recovery is questionable, considering all the problems faced by the misuse of technology; however the qualification of incorporation and spaces generally stranded (roofs) are directly associated with the increase in the construction area.

The item that addresses again the issue of sealing and confirms the conflicts identified in the first group. Of the respondents, 70% say that the layers of waterproofing is protected by GRs, as confirmed by Köehler (2003), Peck and Calaghan (1999); Ingleby (2002). The affirmative for this item is in disagreement with all the issues raised at the beginning of the search for the theme, demonstrating how much we need more information on the subject.

The aspects of the protection acoustic, thermal, energy saving and reduction of flood had a degree of agreement over 50% in all cases. Meanwhile, the benchmarking of this subgroup showed an inconsistency when 37% of professionals deny the environmental benefits offered by GR. You can ascertain that the respondents have no clear understanding of the attribute "environmental" or that the type of answer was influenced by the length of the questionnaire.

The ease in approving projects and incentives of the legislation also has high rates of positive responses: over 75% and 90% respectively. Whereas there is no specific legislation on the subject, perhaps there was an error of interpretation by the respondents regarding other incentives offered by the municipality for green areas, permeability and occupancy rate of buildings in Curitiba.

#### **5.5 Group 5 - Final evaluation**

- Barriers to the spread of technology GRs The issue "change of cultural habits" achieved the highest score (more than 27%), pointing to the importance of changing customs favoring changes in architecture. This result, for another angle, can mean a good thing, indirectly demonstrating the favorable opinion of the respondents to the solution of GRs. Then the technical training of designers and builders was

identified by 28% of respondents to the spread of GRs not as an alternative to recover of roofs. Important emphasize that the public investigated, with a predominance of professionals with only course for graduation (50%), indicates the issue of qualification as the second item of great importance.

Meanwhile, the "need for research and development", which moves in parallel with the qualification of professionals, received only 15% of responses. The "consumer market" was in the same range, indicating that professionals have the perception of the priority of cultural change before the creation of the consumer market. These issues were followed closely by alternative that points to the need to "encourage government" with 10% of responses. The latter item was key to the development of modern technology of green roofs in Germany since the 1970's and the twenty-first century in Canada and USA (PECK AND CALAGHAN, 1999; KÖEHLER, 2003; INGLEBY, 2002; LIU, 2003). In the small percentage allocated to the item to see a low expectation of respondents in relation to government incentives.

- Verification of knowledge by association of examples

At issue in which participants are invited to cite examples of GRs in MRC, is the predominant abstention (44.8%), considering the affirmative group of 2 ° (questions associated with images) on work experience / knowledge. Examples vague and imprecise reach almost 15% and the negative outweigh the 19% of respondents. Only just over 20% cite examples that can be proven.

- Request for additional reporting, criticism and suggestions

When asked to help with criticisms and suggestions, in quantitative terms the response was less than expected, with the omission of over 65% of respondents. Meanwhile, all critical positive or negative events were of great value to the continuation of work and evaluation of the survey as a whole. This was also the space for expressions of appreciation for the initiative of research, technical concerns, real professionals catharsis, showing a real lack of information on the matter.

## **6. Conclusions**

Considering the participants belong to the formal market, one of the study topics is the professional updating required by the market. Another issue deserving specific investigation are the ways found by the individuals to keep themselves updated without necessarily going through the academy. Taking into account the level of knowledge of each professional as a reference for the knowledge of the client, it is the inclusion of the general public between those who deserve more information about GRs. This could happen through examples of successful GR, lectures and short courses in fairs, architecture, decoration and landscaping

exhibitions, building materials shops and general dissemination of the subject in the media.

It appears that the waterproofing - critical issue for the success of technology - is not the domain of the respondents, whichever erroneous concepts about the proper techniques for the establishment of a GR. The misinformation about the benefits offered by the GRs and the urban construction is also verified. Meanwhile, the open questions and direct contacts by electronic mail of respondents were in rich sources of evidence, indicating how much of the architecture and engineering professionals eager for information and clarification on the issue. Examples of GRs show that, even so unintentionally, is being built GR in MRC. The widespread diseases in slabs with vegetation identified MRC testify in the misuse of technology, pointing to the difficulty of reconciliation projects and tasks within a work, the lack of technique, their innovations and their environmental scope. They want provisions regarding the qualification of professionals, manpower and especially the integration between all actors involved in the process. In parallel with this step, the public can stimulate the incorporation of this technology to benefit the urban quality of Curitiba and the entire metropolitan region, as the examples of successful partnership, in the cases of Germany, Austria, Canada and USA.

The survey's results as well as reports on the state of the art of GRs will be forwarded to the participants who asked for this kind of feed-back. Moreover, a specific report on the background failures found in the surveyed community will be forwarded to the Coordinations of the Architecture and Engineering Courses in Curitiba. This is intended to highlight those failures with respect to the curriculum of each course. A similar communication will be established with their professional associations and councils (IAB, Institute of Brazilian Architects; CREA, Regional Council of Engineering and Architecture; and IEP, Paraná Engineering Institute), aiming for the development of professional updating courses and a GR prototype to inform the general public about the technology and its benefits.

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