São Paulo - Brazil - May - 22nd to 24th - 2013

4th Academic INTERNATIONAL WORKSHOP
ADVANCES IN CLEANER PRODUCTION

''INTEGRATING CLEANER PRODUCTION INTO SUSTAINABILITY STRATEGIES''

Innovation and Sustainability in the Project of Skyscrapers: A Case Study Focusing an Educational Approach

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Abstract

This paper describes a experiment of proposing the early stages of design of skyscraper, questioning how those mega-structures will interfere over contemporary and future living and respective urban scene. A politic and economical background framed the context but was also flexible enough to not narrow students' imaginations and decisions.

It starts describing the main problems skyscrapers in the 20th Century, proposing new approaches with new technologies and programmatic interpretations of those structures.

A case study presents three significant projects which were considered satisfactory as to represent the pedagogical bias adopted, which was describe as "Problem based Learning"

It ends observing that 70% of the projects collect during 3 years adopted traditional approaches to project, despite the scenario described. It finally suggests that new research should take in consideration not only the module, but the stages where the students are, comprising other modules that can be highly influential.

Keywords: *architectural projects, skyscrapers, technological innovation, sustainable buildings, education towards cleaner production*

1. Introduction

In the last century skyscrapers were considered a challenge as to partake in the urban scene within the main developed cities in the world. Alexander stated that those tall buildings were transformed into unhealthful structures (Alexander 1977, Alexander 1979), good only to increase the profit of their builders. According to that author, skyscrapers disconnect people from urban places, negatively interferes over the surroundings, providing more shadow, less sunlight and overwhelming urban infrastructures. To that author, skyscrapers make mentally ill people as they are forced to live detached from the social life in the urban scene.

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When thought as places to house services and commerce, skyscrapers can be compared to the big sheds, according to the definition of Martin Pawley (1998). Big sheds also interrupt environmental continuity towards others meaningful places in the city, spreading disorientation and detachment. Therefore, they can be seen as anonymous monstrosities in the landscape. Despite big sheds constitute innovations by the usage of massive amount of computational resources to support its activities (Pawley mentioned the proportion of ten computers to each working man) that author claimed that architects and urban designers should change their visions to cope with these phenomena as to decide how contemporary technology could be transformed into a new and sustainable paradigm.

In this article it will be described a case study focusing a teaching experience with students of the module called "flexible planning", part of the course of Architecture of Federal University of Minas Gerais by the years 2009 to 2012. In this module the students were asked to develop cleaner and sustainable projects of skyscrapers near the Minas Gerais County council. The government has approved a guidance urban plan that will be accomplished in 30 years from now on, aiming the global urban and industrial development, as shown in the fig. 3.

A proposed Economic landscape in 20 years from now on includes a goal of materializing a multimodal corridor of economic value sustained by four pillars: Electronic Components Industry, Info-Tech, Life Sciences Industry and Aerospace and Defence Industry. Supporting those pillars, it was imagined a infrastructure composed by three strong layers: tourism Industry, Education Industry, Distribution Logistics and Wholesale trading Industry (see fig. 4).

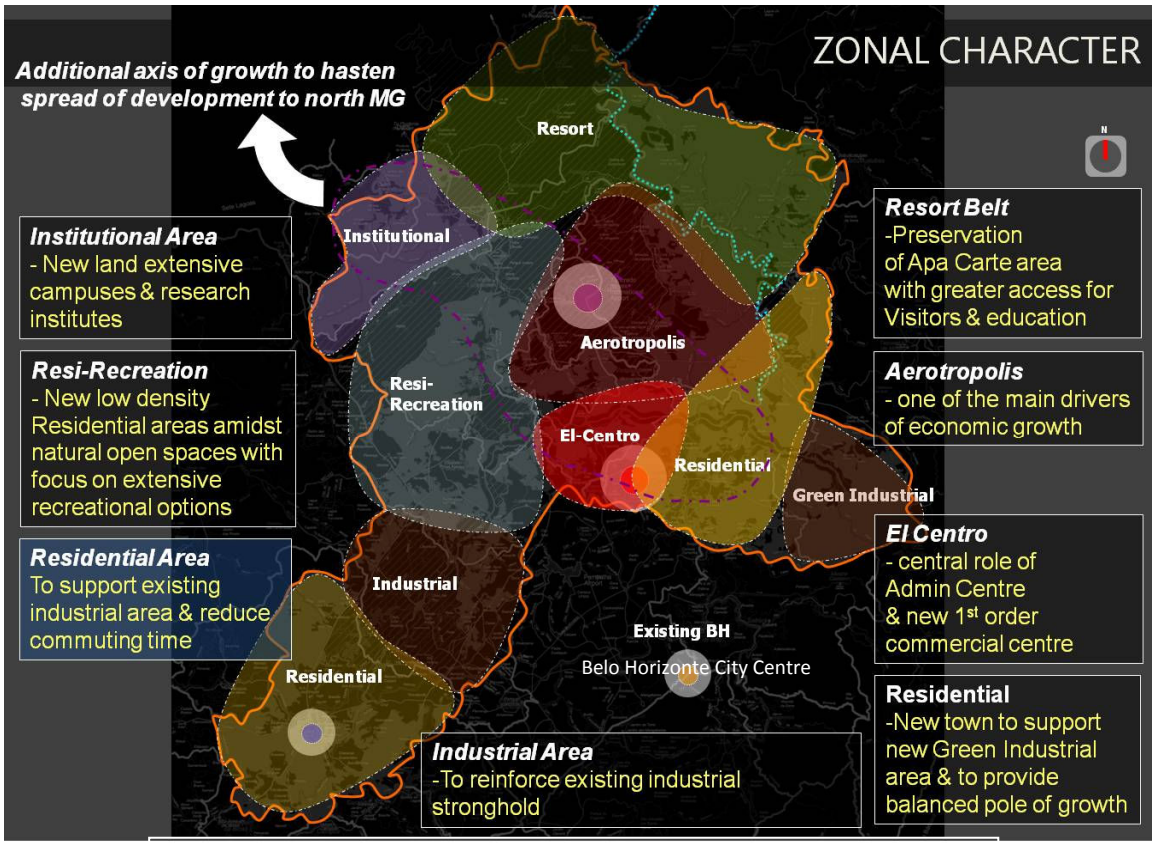

Fig. 3: site for the project of the skyscraper, referred as "El-centro".

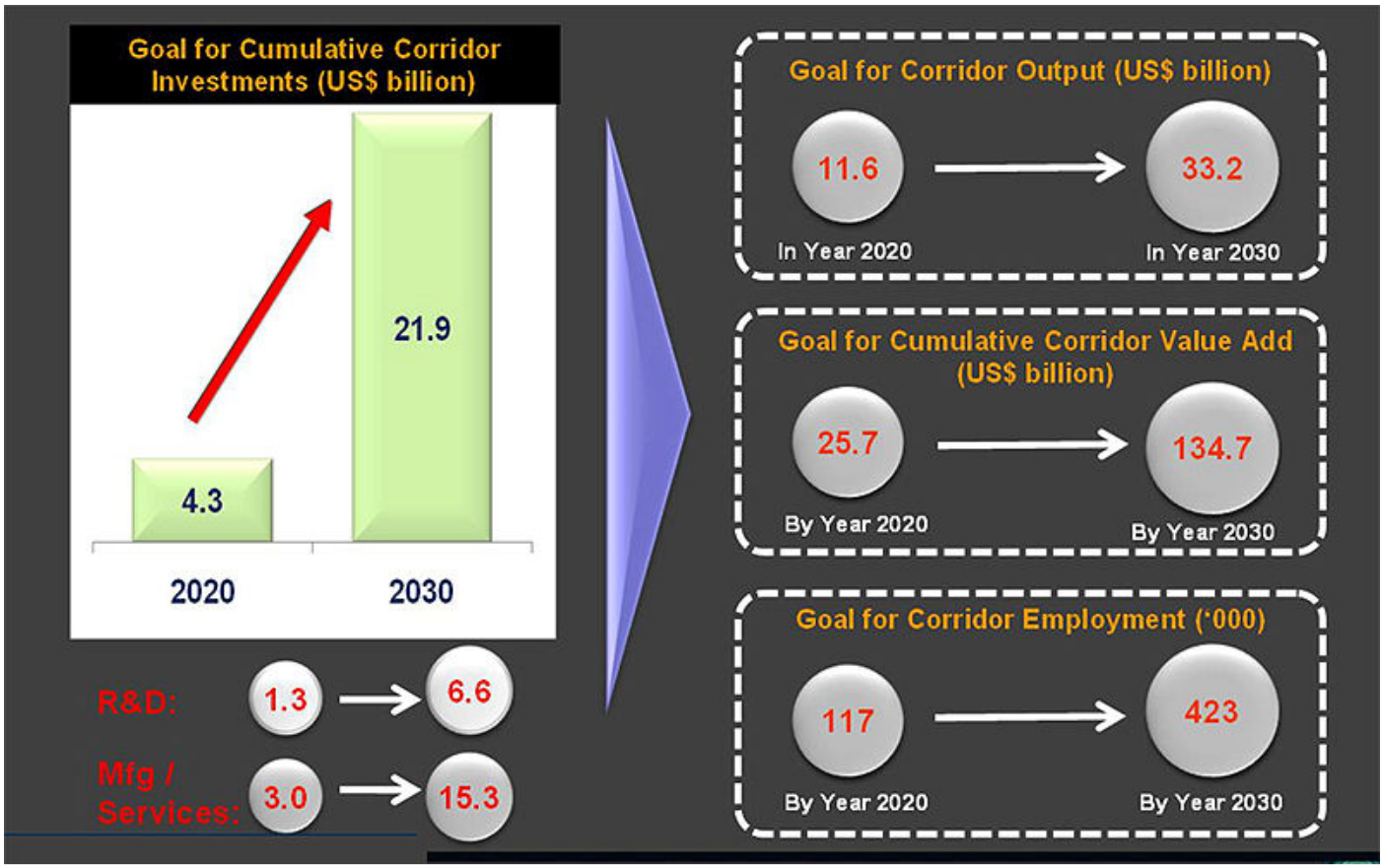

Fig. 4: Prospection of investments in the multimodal corridor

It is noticeable that the plan also contemplates cleaner and sustainable industries, mainly aero spatial and electronic, carefully mixed with residential and institutional areas.

The students were challenged to conceive new approaches in the design of skyscrapers considering the 21st Century technological advances, aiming to change the mentioned conflicts and wondering what are the new responsibilities that those mega-structures bring together. The problem that will be described concern the difficulties to teach and learn under the attempt to create such new paradigm, as mentioned, focusing on cleaner and sustainable buildings and their process.

2. The Problem and the Method

The debate concerning the characterization of what is Science and what is Technology – making clear their similarities and differences - has the essential problem of not giving an explication on how the visible form of Technology - the artefact - comes out from the relation of a wide variety of approaches in Sciences (Takahashi 2009). For instance, in the Physics Sciences (Peirce 1903) the goal is to discover fundamental principles of an natural phenomena, probably requiring a different type of creativity which is more related to the conception of hypotheses to be tested by an experiment, and later, necessarily to be refuted by newer hypotheses, as defended by Popper (Popper 1962, 2002). Technological innovations, however, do not have principles to guide the manufacturing steps, for instance, there is no previous correlation to one in putting together elements as electronic components, principles of electromagnetism, and knowledge about moulding plastics materials in order to create the telly, for instance. By the reasoning above, teaching architectural projects should ask for creativity in the matter of Technology of Construction more than in the design of formal aspects of a Building, neither in the interpretation of its functional requests.

Therefore, our problem was using the early stages of design of skyscrapers to reach principles to a project guidance in order to achieve cleaner and sustainable buildings. That would demand a research

of new technologies, even some announced by the specialized media but not ready to use yet. In doing so, it was expected that this process would reveal the main difficulties that the students would have. Those difficulties and the criticisms and reflections about them will be figure here the conclusions section.

Each module was run bimestrial, by 8 hours a week, with approximately 20 students in each. The period of time to collect the material to do a case study was from the year 2009 to 2012. The case study method was chosen since the type of observed phenomenon (project) is impossible to be treated as divorced from the context of the classroom and all difficulties this implies.

3. Case Studies

Among nearly 60 projects during 3 years were collected and here I am chosen those that are more representative early stages of project ideas to elicit the results in this paper.

3.1. Urban Farming Research Centre

His author explains that nowadays, to feed the world's population of 6.8 billion people, it's needed an equivalent area of entire South America. According to some studies, yet by 2050, with 9 billion people, we may need an area equivalent to Brazil. So, there is a clear necessity to look for new developments of agriculture. Therefore, the proposal of his project does not have intention to present a skyscraper that explores maximum deployment of resources in smallest areas, but it constitutes a first essay where skyscrapers could pop in the skyline of the cities as generic and disseminated resource.

His skyscraper was conceived to be a powerful tool to local city farmers, who will make their experiments and will find the best conditions to produce vegetables and ease their labor. In the midst of many objectives, the building aims to be a center of a local network of urban farmers since the site is in front of a central local as the County Council of Belo Horizonte city, spreading after and establishing a web of distribution of goods within the markets of vegetables in the whole city.

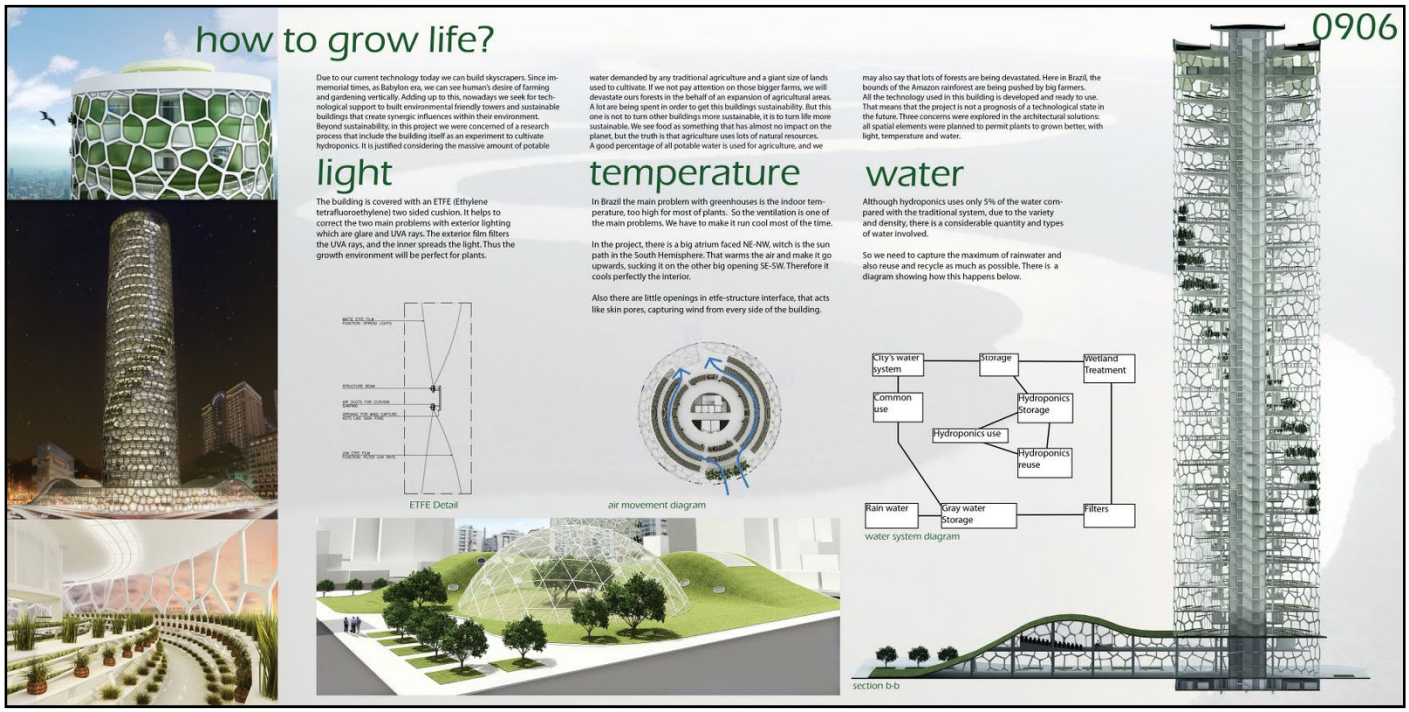

Fig. 5: Vertical Farmer aspects. A core of reinforced concrete support the floors, and the external surfaces are made on a polymer so called Ethylene tetrafluoroethylene, ETFE, a fluorine based plastic, which was designed to have high corrosion resistance and strength over a wide temperature range. They were structured in irregular frames as inflatable Diaphanous walls permitting sunlight inside. Strategic opens were placed in order to use directional winds of the region.

The skyscraper has 24 floors where research concerning hydroponics is developed. It has also an experimental greenhouse dedicated to research plants disease and other greenhouse which research no hydroponic farming. Since the main building is a centre of research in hydroponics, there is also a visitor's center, with restaurant, stores, exposition hall and multimedia room; there is also an analysis center, with labs (researching water, soil, genetic and others) that can support the community; as well there is a loading area and a warehouse. Due to our current technology today we seek for technological support to built environmental friendly towers and sustainable buildings that create synergic influences within their environment.

Beyond sustainability, in this project the student was concerned of a research process that include the building itself as an experiment to cultivate hydroponics. It is justified considering the massive amount of potable water demanded by any traditional agriculture and a giant size of lands used to cultivate. If attention was not paid on those bigger farms, we will devastate ours forests in the behalf of an expansion of agricultural areas.

A lot are being spent in order to get these kinds of buildings sustainable. But this one is not to turn other buildings more sustainable, it is to turn life more sustainable. We see food as something that has almost no impact on the planet, but the truth is that agriculture uses lots of natural resources. A good percentage of all potable water is used for agriculture, and we may also say that lots of forests are being devastated. Here in Brazil, the bounds of the Amazon rainforest are being pushed by big farmers.

All the technology used in this building is developed and ready to use. That means that the project is not a prognosis of a technological state in the future. Three concerns were explored in the architectural solutions: all spatial elements were planned to permit plants to grown better, with light, water and temperature.

Fig. 6: The first building will serve as a prototype. A map of the city centre of Belo Horizonte shows sites where next vertical farms could be build since those sites are near strategic hubs of distribution.

3.2. **Vertical allotment**

This building was designed trying to solve many problems initially mentioned that affect tall buildings. It was conceived as a housing enterprise, called here as "allotments" which is a reference to the British allotments created to support the citizens since the Second World War. It also stimulates differentiate occupations by their inhabitants (see figs. bellow).

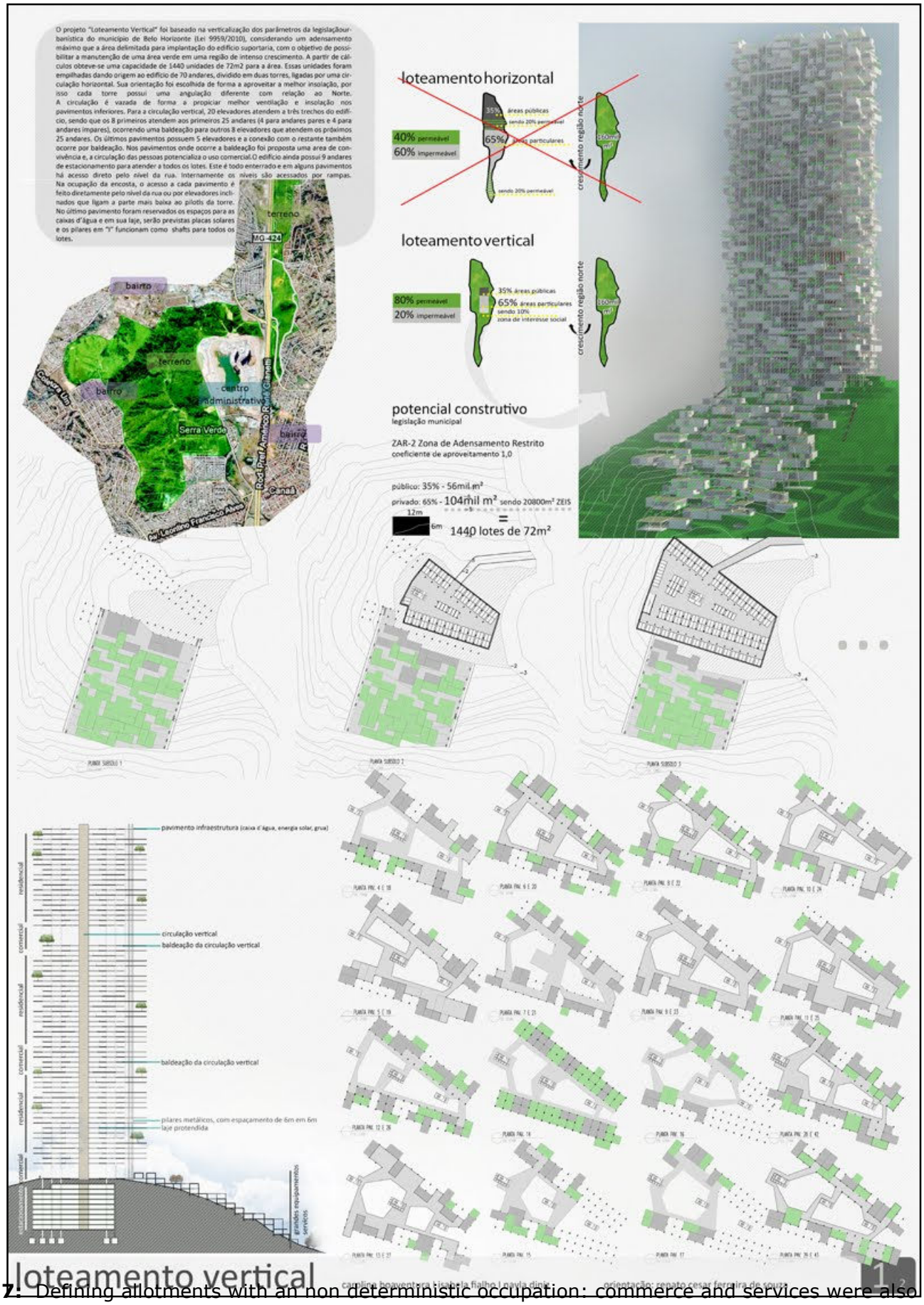

Fig. 7: Defining allotments with an non deterministic occupation: commerce and services were also planned in special floor. The metallic structure was chosen to cope with the variety.

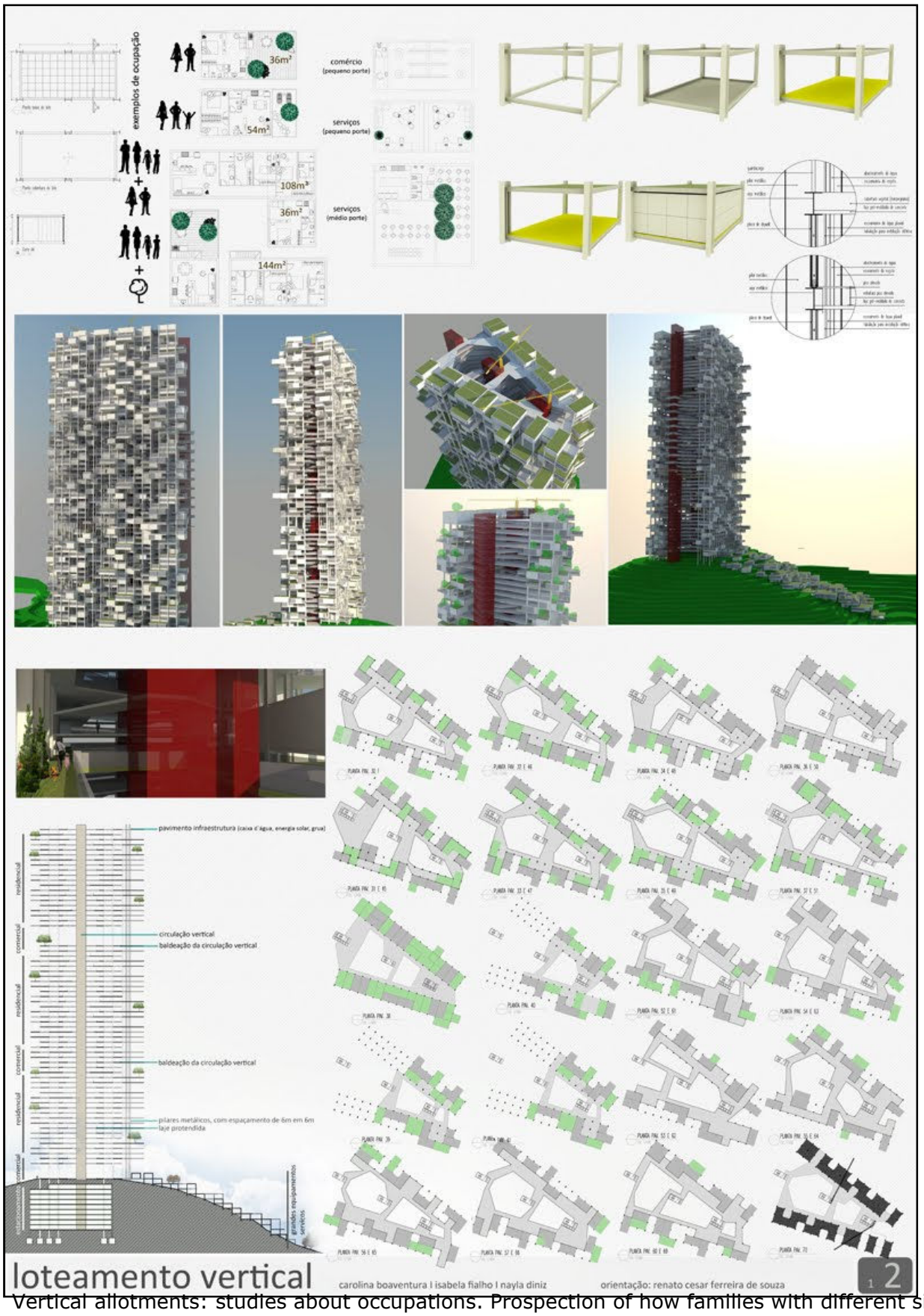

Fig. 8: Vertical allotments: studies about occupations. Prospection of how families with different sizes and needs could occupy the floors (technical studies) and visions of the ambience and formal aspects for the whole building intended by the author.

3.3. **Vertical Aerotropolis**

Aerotropolis are new urban form placing airports in the center with cities growing around them, connecting workers, suppliers, executives, and goods to the global marketplace. They aim to offer speed, agility and connectivity with the main hubs all over the word. In this case, the two authors decide putting the airport in the top of the city, instead encapsulating it surrounding it by the city. They considered moving the actual airport Tancredo Neves to a frontal position with the County Council.

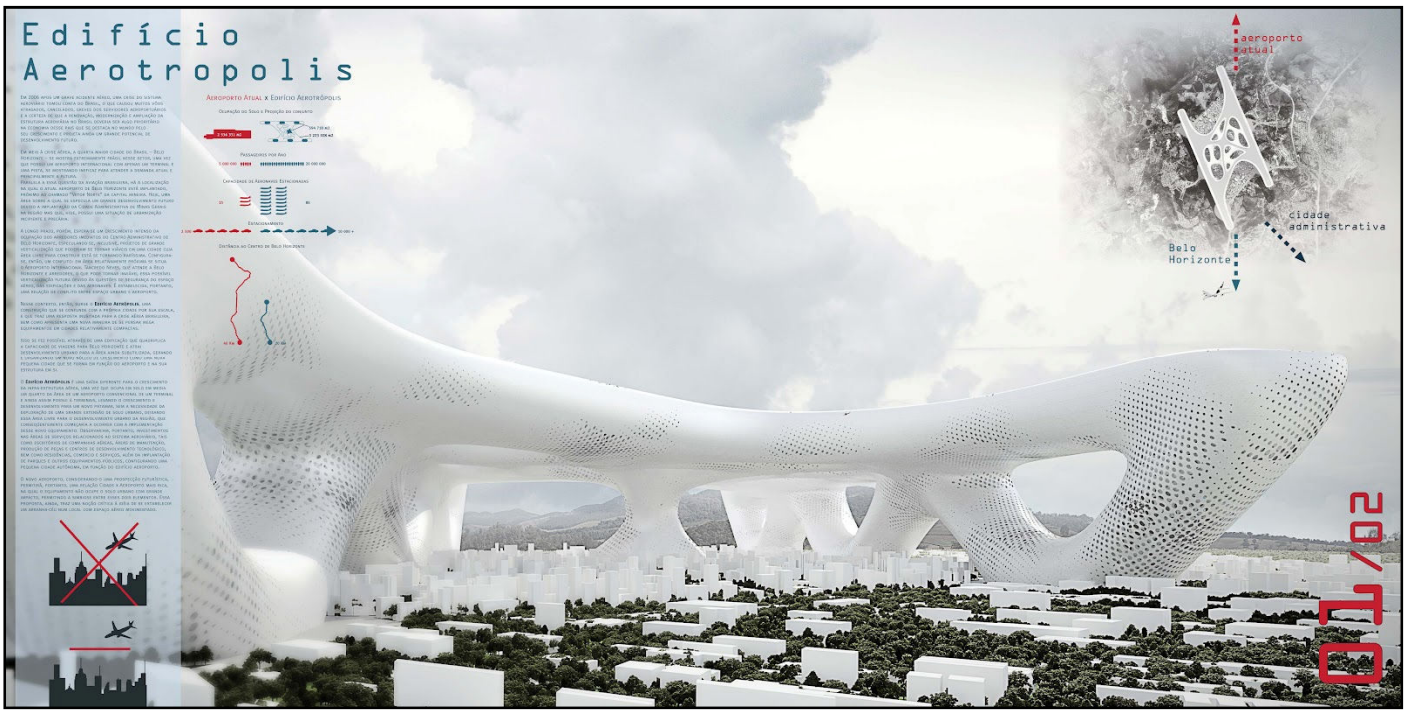

Fig. 9: Vertical airport and aerotropolis. A scheme in the right up corner shows the position of city centre, County Council and the old airport.

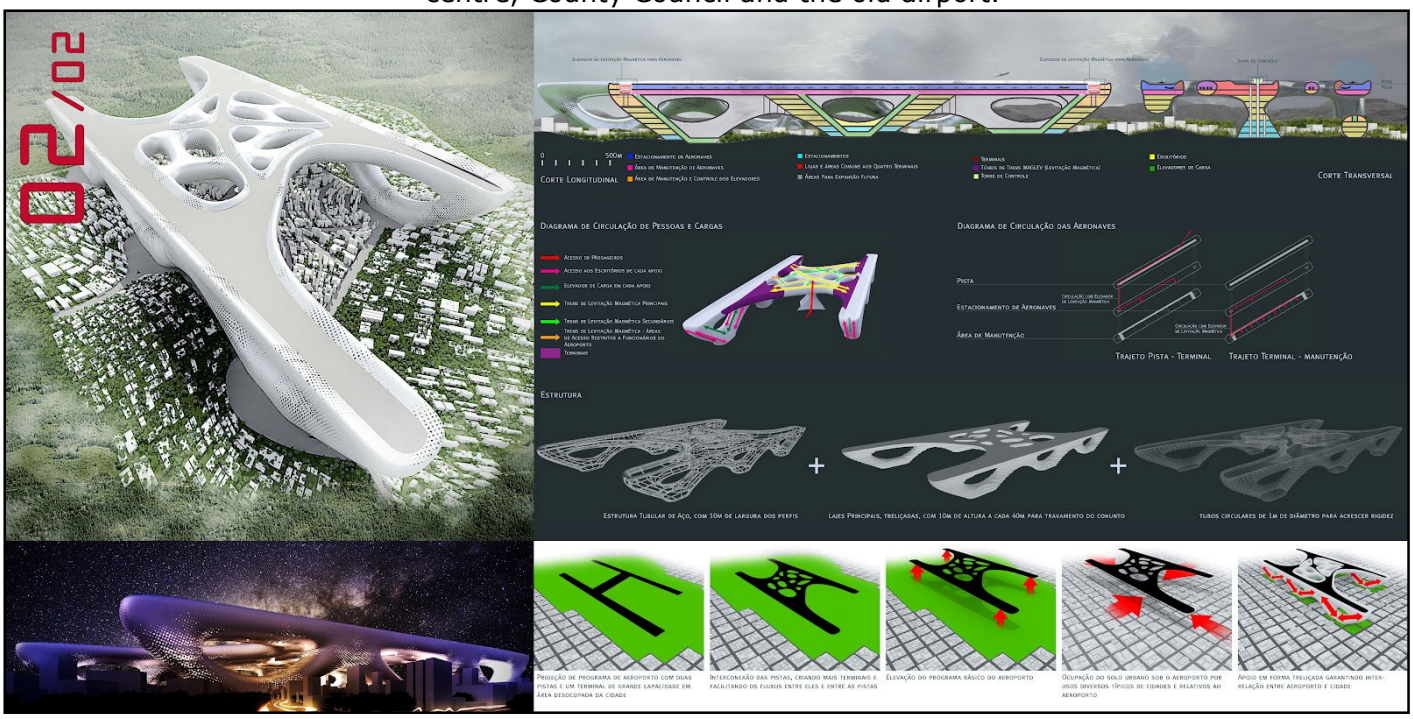

Fig. 10: Views of the Vertical airport and aerotropolis. Schemes show the building process stages and the functional occupation by floors.

The aerotropolis has a interlaced structure of composite material (carbon fiber, glass fiber plus metallic structure) creating the giant columns, inside which it is placed the others spaces needed. Since the planes runaway are disposed as to conform holes in the structure, it would be possible occupying underneath the building with supportive housing, commerce, hotels, distributions centres among others. Those structures are connected with the rest of the county by tube or

4. Conclusions

Many other projects could be included here as to o illustrate the attempted of creating a teaching focusing on cleaner and more sustainable building process. But those examples can be described over a pedagogical background from which they help to clarify some important aspects.

It was observed that less than 30% of the skyscraper´s projects coped satisfactorily with the challenges introduced in the three levels, during 3 years: the economic background, the challenges in the use of new and sometimes not clearly defined technologies and the ability to go further traditional programs to the buildings. Many of the 70% dedicated their programs to traditional/conventional mixed use, keeping the sense of a old educational project training. So, in the range of 70% were plenty of projects depicting commerce mixed with hotels and services, all of them taking in consideration the actual state of the proximity to the County Council. Rarely a project accepted the fact of being accomplished in the period of 30 years. So there was an inertial force in the imagination of the students, blocking their creativity.

In terms of a pedagogical strategy and its didactical reflex, it was considered the process now well know as Problem-based learning (PBL) which is a student-centered pedagogy (McKeachie 2006). The students learn about a subject through the experience of problem solving. Students learn both thinking strategies and domain knowledge. The goals of PBL are to help the students develop flexible knowledge, effective problem solving skills, self-directed learning, effective collaboration skills and intrinsic motivation. Normally problem-based learning is a style of active learning.

So, working in groups, students identify what they already know, what they need to know, and how and where to access new information that may lead to resolution of the problem. It was what happened mainly in the decisions of structural and other material they should choose. Aeronautic course and the Centre of Technology of Minas Gerais offered them supportive lessons in class as to give them appropriate power of decisions.

In PBL, the role of the tutor is to facilitate learning by supporting, guiding, and monitoring the learning process. The tutor must build students' confidence to take on the problem, and encourage the students, while also stretching their understanding. Even so, intrinsic problems pop during the process: traditional pedagogy process, in other modules that was running at the same time, focused in occlusive perspectives of Brazilian building technology, giving the lack of confidence as to use the design as an imaginative orchestration of technologies and materials.

The fact that only two months were taken to students produce the projects does not mean a limitation, since the schematics drafts were quite expressive and quicly to create, exposing ideas.

Future research should expand the horizon of this analysis considering the entire pedagogical background that submit the students in that moment, as to see their influential capabilities over the creative solution to cleaner and sustainable solutions.

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