

WORLD HERITAGE and DEGRADATION Smart Design, Planning and Technologies

Le Vie dei Mercanti _ XIV Forum Internazionale di Studi

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ID 262 The hidden villa. Virtual modeling in survey of Villa
Farnesina in Rome

Alessandro BIANCHI

Politecnico di Milano, Italy

ID 165 Smart buildings and connections, a case study for
India

António MORAIS, Soheyl SAZEDJ

University of Lisbon, Portugal

ID 180 The Structural Redundancy in the Pombalino Sy-
stem

Isabel ROSA, Ricardo RIBEIRO, Joana LOPES

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ID 067 The Landscape Suitability as a sustainable aspect
of Architectural Cultural Heritage. Case study of Ria
Formosa Natural Park.

Julian RENNIE

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ID 006 Collected and Collecting in Christchurch, New Zea-
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ID 034 A revival project for the cultural heritage of Ginosa

Vincenzo BARRA

Pegaso University Naples, Italy

ID 025 Bristol travellers in the Italy of the eighteenth cen-
tury: landscape, art and culture



Le Vie dei
Mercanti

XIV International Forum

WORLD HERITAGE AND DEGRADATION

Smart Design, Planning and Technologies

Aversa | Naples 16 - Capri 17, 18 June 2016

Smart buildings and connections, a case study for India

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Abstract

This abstract reports about an architectural research about material and immaterial networks, when some small and smart buildings are intended as the basic regenerative cells of smart cities, a hi-tech key element allowing them to evolve towards the model of a clever and connected infrastructural grid. This is the objective that has animated the activity of a team including the author and formed in the framework of an advanced design course experience within the Alta Scuola Politecnica (ASP - High Polytechnic School, jointly organized by the Polytechnics of Milan and Turin) to define the virtual connections generated by a small building: a sustainable, energy independent clinic conceived for bringing basic health care services into poor and overpopulated developing contexts, like slums around high-density cities. The idea underlying the whole research is that to speed the improvement of socially disadvantaged micro-contexts, implants of mostly cheap energy and clean, cheap water, condensed in a few, small smart-tech “hubs”, can play a fundamental role in activating a virtuous interplay between economic competitiveness and environmental healthiness; and that this can in turn contribute to lower the barriers between city slums and their surroundings. Smart cities, smart buildings, sustainable architecture, energy, models and images of representation, material and immaterial connections.

Keywords: connections, networks, sustainability, social

The challenging goal of the project is designing infrastructures to provide health care and basic services in developing countries, in complex situations such as slums or bidonvilles, inserting buildings able to produce energy where it is needed without transportation. The practical idea is to implement several small, prefabricated clinics to have a fast, cheap and sustainable solution but also be able to provide services for a long period and offer a starting point for local development.

The case study to design the general concept is a slum area in New Delhi of 6 square km where we designed the construction of 4 clinics, able to provide medical services and clean water, within a maximum walking distance of 1km. The New Delhi slum area is located near the center of the city, bordered by the railway tracks. The slums are a primary choice for the location of the clinics because of the high density of the living conditions and the lack of hygiene services, such as adequate toilet facilities and clean water. This population is at risk for illnesses related to lack of hygiene, contagious diseases, etc., meaning that they have more need for the kind of basic healthcare that our clinics are designed to provide. Additionally, we have planned many small clinics instead of one large one in order to serve the local population more affectively, allowing them to access a health clinic within walking distance of their residence and receive more personalized care.

The clinics are all standardized and with the maximum grade of prefabrication to cut costs. This idea allows us to build a relevant number of pieces in a central place, reducing the costs and the time of construction at the location. From the architectural point of view, we try to respect both the local construction tradition and energy issues. To do so we compare different solutions for each building element (envelope, roof, openings etc.) in order to give different possible configurations. By doing so we give our stakeholders the possibility to choose among different features in order to make the building suitable for different situations all over the



Le Vie dei
Mercanti

XIV International Forum

WORLD HERITAGE AND DEGRADATION

Smart Design, Planning and Technologies

Aversa | Naples 16 - Capri 17, 18 June 2016

world. After the comparison, we have focused our case study in New Delhi, deepening the solutions that are more suitable for our location, according to their availability and respect for the context. The other main

requirement is sustainability, which means satisfying all the energy needs with green energy (considering that slums do not have electricity). To reduce the energy demand we use passive cooling strategies together with high insulation, in order to reach a high level of thermal capacity without using massive construction techniques. The shape of the building is simple and compact, in order to reduce the energy waste and fit into the dense urban fabric of the slums. The entire building is developed on one single level, while the only cutting off element being the movable platform of the solar panels on the roof.

The project initiated with the conception of a sustainable public building, such as a school or a medical clinic, that could provide a stimulus to the surrounding community. The project was conceived as a resource for developing countries, in order to promote social and economic development in a sustainable way. The building was intended to provide essential resources to the community, such as technological resources, electricity, or special services. In this way, the building could act as a catalyst for the further development of the neighbourhood.

From the beginning, an important element of the project was the desire to design a sustainable structure that would be versatile enough to function in a diverse range of environmental conditions, while at the same time remaining cost effective and maintaining a highly sustainable methodology. However, a fundamental challenge in the project developed is the desire to design a geographically versatile building while at the same time minimizing the transportation of materials. These two desires were in some ways contradictory, since the need for geographical versatility suggested a prefabricated design that would be manufactured off site, while the desire to minimize the transportation of materials suggested the use of a highly customized design using local materials. We have attempted to solve this dilemma by using a partially standardized and prefabricated design, while allowing for customizable elements, in order to make the building functional in a wider range of environments and also allow for the use of local materials and building traditions.

Since it was necessary to customize some aspects of the building, India was selected as a case study for the project. The specific case study location in New Delhi, India was selected for a variety of reasons, primarily involving environmental and economic conditions. For instance, India is sufficiently developed in order to provide access to local materials and industries that can be used to develop the essential elements of the project, such as steel, bamboo, and cladding materials. This was an important consideration because using local materials was a principle aspect of the design. Furthermore, the function of a medical clinic was chosen as opposed to a school because of the higher technical requirements involved. Because our building design has many technical aspects, including rotating solar panels, it is more suitable and cost effective as a clinic.

Another important aspect of the project was the development of a rotation system for the solar panels. The process involved optimizing the system's rotation capabilities in order to maximize the energy output in the most efficient way. The configuration of the rotation system was developed as the main innovation in the project, and the overall concept of the project evolved further around this innovation. Using the rotation system, the goal was to produce a large amount of energy in a small area, while keeping the building's energy consumption low, so the reliability of the health services is guaranteed and the surplus energy could be supplied to the surrounding community.

Thus the original idea of a public building acting as a social stimulus developed further into the concept of a diffused power plant. The diffused power plant concept involves the implementation of an array of high-energy producing buildings that can act as a power plant for the community, ideally relying entirely on renewable energy sources. The implementation of a diffused power plant could eventually replace the centralized power plant, keeping energy production inside the city and reducing the need for energy transport, creating in a practical way the concept of smart city. This concept requires further analysis and innovation; however, the focus on energy is especially relevant considering that the United Nations' goal is to provide electricity to everyone in the world before 2030 (United Nations Foundation, 2013). The need to increase our global energy production is complicated, considering the environmental consequences of typical energy production methods; therefore it is crucial to reach this demand in a sustainable way. According to the diffused power plant concept, innovations in architectural design and renewable energies may provide a solution. Although the specifics of our project have been developed around our case study in



WORLD HERITAGE AND DEGRADATION

Smart Design, Planning and Technologies

Aversa | Naples 16 - Capri 17, 18 June 2016

New Delhi, it is important to keep in mind that the location of the building is adaptable. The function of the building is also adaptable. It can be used as a public building, such as a school or clinic, but it could also function as a private residence. The aim is to provide an affordable and sustainable building solution that can offer a positive output of green energy and can be modified to function almost anywhere in the world. The project stakeholders include local governments, humanitarian aid organizations, environmental organizations, architecture and technology companies, such as PV panel producers, and the local residents in our case study. The requirements vary for the different stakeholders and the project attempts to benefit all stakeholders by not only focusing on sustainability, but also social considerations and the need for economic development in the third world.

The aim of our project is to provide a sustainable solution to medical treatment in the third world, using an innovative combination of high-tech and low-tech solutions. However, our project does not define sustainability as simply an environmental issue, but rather seeks to approach the concept of sustainability from three sides, considering the social and humanitarian needs of the residents, the environmental sustainability of the overall project, and the need for local economic development.

Social Considerations

The social issue develops from the need for humanitarian aid in the form of medical assistance and the provision of basic services to improve the standard of living and future opportunities of families living in slums. The following features demonstrate how the relevant social considerations have been implemented in the project.

Project Features

- Micro Clinic within Walking Distance
- Provision of Additional Services"
- Socially Accepted Design"

Environmental Sustainability

A central theme in the project was the desire to develop a sustainable architecture solution for public facilities in the third world. The premise was that sustainable solutions do not have to be expensive or even high tech. There is a need for development to be thought of from the sustainable perspective, no matter where the project is taking place and no matter the budget. All types of projects can benefit from sustainable ideas. Sustainability should not be considered as an obligation, but as an opportunity for creativity and progressive thinking.

Project Features

- Energy Independent
- Local Materials and Labor

Economic Development

A third feature of the project involves economic development. From the economic perspective, there are two primary concerns: the economic feasibility of the project, and the desire to support sustainable local development. Promoting sustainable development is important in order to provide more opportunities for third-world populations, minimizing the need to provide aid in the future. By offering direct aid, it is possible to improve the current living situation, but the only way to improve future autonomy is through sustainable development initiatives.

- Local Materials and labor
- Pre-Fabricated Design



WORLD HERITAGE AND DEGRADATION

Smart Design, Planning and Technologies

Aversa | Naples 16 - Capri 17, 18 June 2016

Project Requirements

After a social and urban analysis of the slums, we can now adapt our general idea for the implementation of the clinics to the specific context. The requirements introduced in the previous section are now explained in more detail and contextualized.

Micro Clinic within Walking Distance

By using a micro clinic design, rather than a larger medical center, the project aims to provide a better experience for patients, with more personalized care. With small clinics located 1km apart, patients do not need motorized transportation to reach a clinic. This is crucial because slum residents do not have access to cars and the narrow streets make it difficult for emergency vehicles to enter slum areas.

Provision of Additional Services

Furthermore, the clinics are designed to provide additional services such as clean water and health education, in order to improve the unhygienic conditions of the slums and reduce the spread of preventable illnesses. Health education is an important aspect of disease prevention. Although the majority of the slum population is literate (70%), they are lacking important health information regarding hygiene, child and pre-natal care, and the health risks of certain behaviors, such as smoking and drinking. Disease prevention through education is as important as disease treatment, and the small, localized design of the clinics is convenient for the distribution of educational materials and information at the neighborhood level.

Socially Accepted Design

Clinics are meant to satisfy the immediate needs of the population and also to stand the test of time and provide services for decades. In this direction they have elements thought to be merged with the urban context and be perceived as a positive nucleus for the development of health and society. For these reasons, the architecture of the clinics recovers some aspects of the local tradition, such as the entrance with arches and an open space."

Energy independent

The implementation of our public buildings is thought to be possible also in areas not connected to the electrical grid, without reducing the quality of the services provided. Health assistance needs some electric devices and the clinic of course must be provided with adequate lighting and a cooling system to cool the environment and medicines. To maintain these high quality services, the design of the clinics has moved in two complementary directions: smart tools to reduce the energy consumptions and a system able to provide electricity. To reduce electricity usage we adopted low consumption lights and a heat pump able to provide heating and cooling with a small usage of electricity. However, our biggest efforts were in the direction of increasing natural light and maximizing insulation and natural cooling systems. In this way, choosing materials wisely and designing a smart architecture, the energy needs of the building were reduced. The production of electricity is entrusted to an innovative photovoltaic system, intended to provide the requested electricity while minimizing the costs. To achieve the goal of sustainability and match the real needs of the population, when a surplus of energy is present it is used to purify water, in order to face one of the trickiest problems of the case study location.

Local Materials and Labor

This requirement has the dual purpose of reducing the use of transportation resources and involving local producers and manpower in the construction of a public building. First of all, using materials that can be found locally reduces the costs for the clinic and also stimulates local economies, increasing the social utility of the buildings and making the clinics more accepted. This goal has been achieved by integrating bamboo and steel in the structure, and using natural and local materials with excellent insulation properties for the envelope. The bamboo solution is deepened in the chapter about structure, while the characteristics of the envelope materials can be found in section 4. Additionally, using natural and organic materials, we have a more sustainable building in the whole life cycle, minimizing the environmental impact of the demolition and waste treatment.



Le Vie dei
Mercanti

XIV International Forum

WORLD HERITAGE AND DEGRADATION

Smart Design, Planning and Technologies

Aversa | Naples 16 - Capri 17, 18 June 2016

Prefabricated Design

The clinics are designed to be easy to assemble, with a high grade of pre-fabrication to cut costs and time. The intervention to provide a social service in critical areas has to be fast, because health is a crucial issue in these areas. Moreover, the urban situation in developing countries is so changeable that a fast

implementation is a key requirement. High grade pre-fabrication reduces the assembly time and the collection of material in a central place is easier and cheaper. The IKEA logic of pre-fabrication, easy and well-explained assembly is also a way to avoid the problem of non-specialized manpower.

The main goal of the pre-fabrication and standardization of the clinics is cutting costs. Although this methodology limits the customizability of the building, it allows us to produce a larger number with lower specific costs, and this fact is crucial for the energy system, for example. Moreover, in this way, it is possible to exploit economies of scale in the production of structural components, maximizing the assembly phase in the place of production. The limit for the grade of pre-fabrication is represented by transportation constraints for our case study in Delhi.

Conclusions

The designed prototype turned out to be not only a building, but also an implementation strategy for confronting the issue of providing public services in a variety of complex high- density areas. Standardization and prefabrication have been here used to keep costs low without renouncing to high standards of services. The centrally-managed collection and production of materials before delivery makes the process of assembling and construction easy and fast. A possible follow- up of this effort could be refining the system of packaging and instructions for non-specialized skill labor, on the example of the IKEA model. This may involve all constituting elements of the building and inform the whole entire process. The improvement of a well-defined and simple intervention model could be interesting for non-profit humanitarian organizations as well as for governments interested in cost-effective solutions.



Le Vie dei
Mercanti

XIV International Forum

WORLD HERITAGE AND DEGRADATION

Smart Design, Planning and Technologies

Aversa | Naples 16 - Capri 17, 18 June 2016



Fig. 1: Map of Clinic Positions in the slam area for New Delhi



Le Vie dei
Mercanti

XIV International Forum

WORLD HERITAGE AND DEGRADATION

Smart Design, Planning and Technologies

Aversa | Naples 16 - Capri 17, 18 June 2016



Fig. 2: Example of a slam at New Delhi

The diagram illustrates the layout of a mobile medical unit. The main floor plan includes a waiting room (31 sqm), five exam rooms (each 7.8 sqm), a pharmacy/laboratory (7.8 sqm), a WC (2x 3.9 sqm), a machine room (7.8 sqm), and a cloakroom (7.8 sqm). The unit is equipped with various medical and diagnostic tools, including a microscope, ultrasound, X-ray, and a stethoscope, as indicated by icons on the left. On the right, icons represent patient flow, clothing, and medical equipment.

XIV International Forum



Le Vie dei
Mercanti

XIV International Forum

WORLD HERITAGE AND DEGRADATION

Smart Design, Planning and Technologies

Aversa | Naples 16 - Capri 17, 18 June 2016

SURPLUS OF ENERGY



PURIFYING WATER



GIVE ELECTRICITY TO THE GRID



PROVIDING FREE WI-FI

Electric needs and surplus with the final configuration
(azimut tracking 30° tilt)

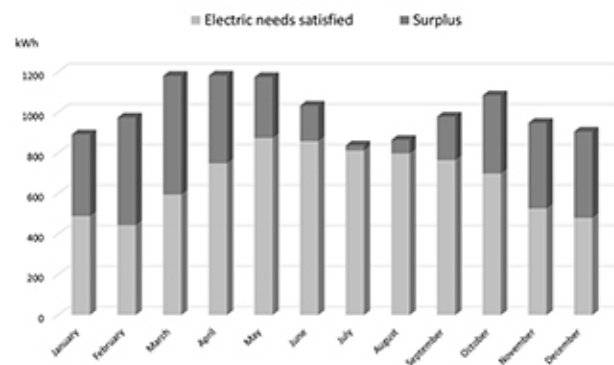


Fig. 5: Tools using surplus of energy



Le Vie dei
Mercanti

XIV International Forum

WORLD HERITAGE AND DEGRADATION

Smart Design, Planning and Technologies

Aversa | Naples 16 - Capri 17, 18 June 2016

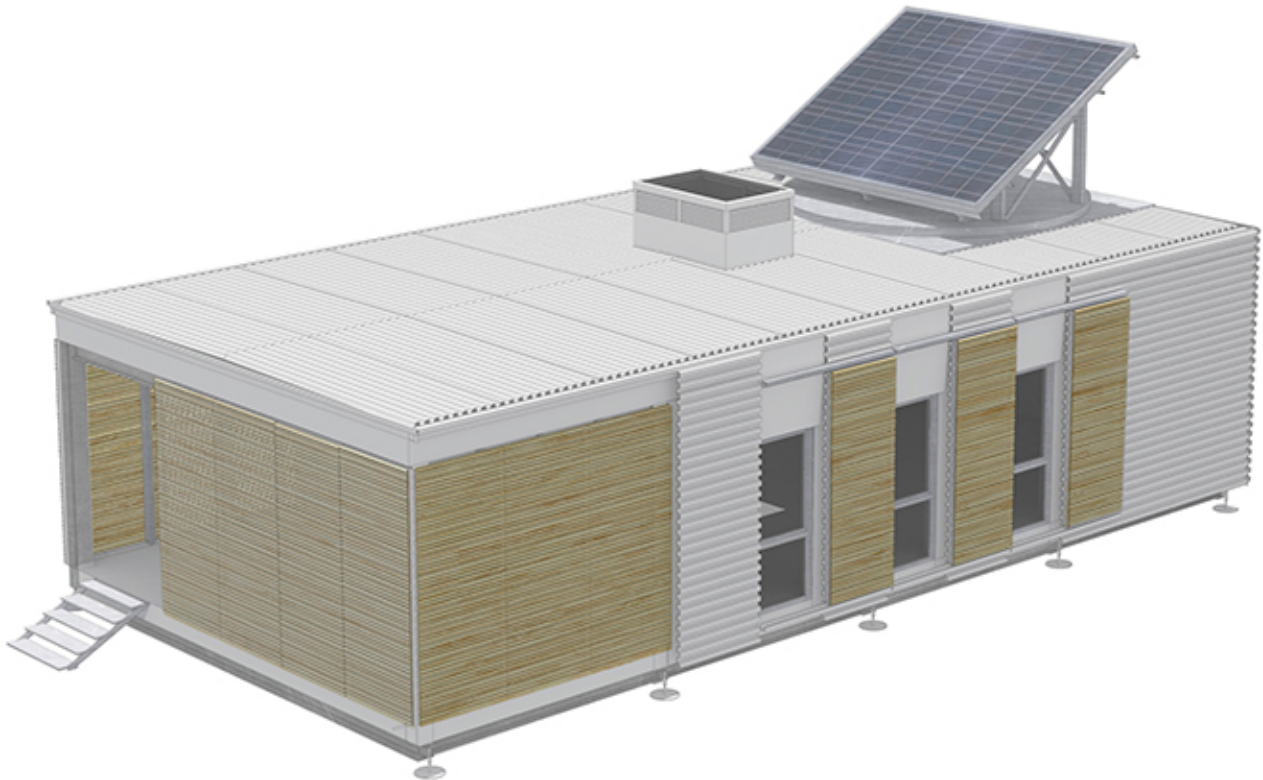


Fig. 6: Model of smart clinic



Le Vie dei
Mercanti

XIV International Forum

WORLD HERITAGE AND DEGRADATION

Smart Design, Planning and Technologies

Aversa | Naples 16 - Capri 17, 18 June 2016

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Le Vie dei
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WORLD HERITAGE AND DEGRADATION

Smart Design, Planning and Technologies

Aversa | Naples 16 - Capri 17, 18 June 2016

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Le Vie dei
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Smart Design, Planning and Technologies

Aversa | Naples 16 - Capri 17, 18 June 2016