Sustainability as Driver of Architectural Practices
San Francisco federal building case

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ABSTRACT: In the context of depletion of ecosystems due to the effects of buildings on the environment; several initiatives have emerged. They aimed to reduce the impact of buildings on the natural environment. 2030 challenge, rating systems, green standards and other building codes seek to raise awareness of sustainability in construction. The potential of buildings to contribute to the well-being of occupants cannot be limited to satisfaction of human needs. Building practices need to experience a paradigm shift. The old mechanical view of the built environment as a giant mechanism composed of machinelike pieces is being replaced by new concepts. The ecological discourse is changing the way that architecture is conceived. Synergy and dynamics between man made and natural systems provide opportunities for innovation to respond to environmental challenges. New developments and technologies would play a major role in the paradigm shift. This paper presents the case of the San Francisco Federal Building led by Tom Mayne, architect of Morphosis. The holistic design approach of this multidisciplinary project is presented; identifying strategies and technologies that enhanced the performance of this green building. The contents of this discussion are aligned by the ecological rationale of sustainable architectural practice of recent years.
Keywords: eco-technology, holistic design, sustainable architecture

INTRODUCTION
Green built environments should aim to respond to quantitative and qualitative targets guided by sustainable principles. Sustainable buildings should account for aspects such as energy flow, environmental loadings, building quality, serviceability, and lifecycle. Every stage of the building's life involves different dynamics of consumption and waste.

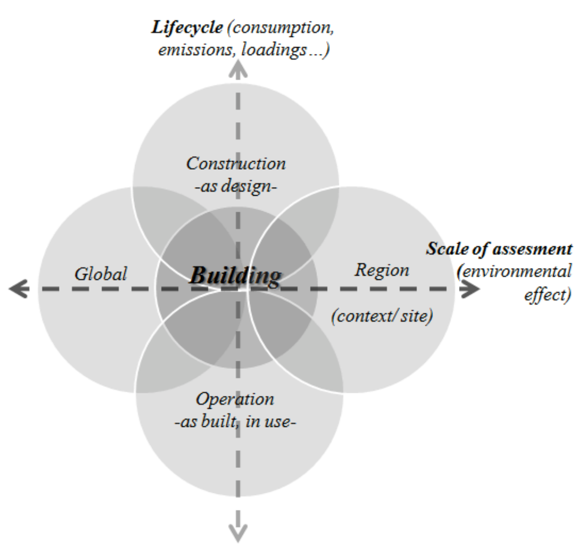

Figure1. Dynamics of interactions between building and environment

Design, construction, operation, deconstruction and demolition produce changes in the way that buildings interact with the environment. Buildings can produce stress on natural systems both as consumers and as producers of waste. They use a great amount of resources during their life cycle (materials, energy and water). They also produce pollution and emissions that aggravate the critical environmental situation.

Sustainable architecture should aim to create greener and better performing buildings that respond to this critical situation. Buildings should be regarded as organisms where multiple dynamics take place. Living organisms are highly interdependent on each other and their physical environment [1]. Buildings are not simple products but processes where synergies occur. Sustainable buildings should interconnect set of human, architectural and environmental subsystems [2].

BUILDINGS AS COMPLEX SYSTEMS
The principles that rule most ecosystems should be applied to the design of the human environment. Balance, synergy, interdependence are key aspects to create a harmonic relation between man made and natural systems. As complex systems, buildings can only be understood if they are subject to different levels of analysis. They cannot be considered simple summation of elements. From a holistic perspective, concepts such

as façade, structure, massing and indoor environment cannot be defined in isolation. The simple overlap of components will not enable the optimal use of resources.

Architecture will probably change more radically over the next decades than it has changes in the past hundred years [3]. The profession is confronting a turning point that demands a holistic approach to face challenges related to resource shortages and overexploitation of the planet's carrying capacity. The environmental discourse is required as a framework to facilitate dialogue and critical debate in the industry.

ECOLOGICAL ARCHITECTURE SPECTRUM

Ecological thinking in architecture requires a multidisciplinary approach starting in early design stages. The feedback from diverse professionals in the AEC industry enables the incorporation of technologies and ecological friendly innovations. Green practices can benefit from such integration when including environmental considerations in building design.

Multiple criteria should be incorporated in order to propose environmentally sound and cost effective solutions. The ecological principle 'thinking globally while acting locally' should guide building practices. Environmental inputs are to be used on a sustainable scale appropriate to each bioregional setting [4]. The design goals of early industrialists were specific, limited to practical, profitable, efficient and linear [5]. Unlike these goals, ecological targets should attempt to be eco-efficient and sustainable. Ecological philosophy as the main driver of the creative architecture process provides multiple opportunities for originality. Design thinking should question the way human development processes contribute to the environment that they change [6].

There are two positions concerning ecological thinking in the architecture creative process: ecological and technological sustainability [7]. The first position perceives sustainability as the driver of the practice. The eco impact of the building is the most important aspect to consider. It argues that architecture should learn from the synergies of natural systems. Ecological sustainability considers the balance and integration of components of natural systems and processes to reduce the impact on the atmosphere. The second position involves the use of smart engineering systems and innovations. This perspective is related to the second industrial age. Human beings use natural resources in ways that are environmentally respectful and have awareness of the limitation of resources.

In the spectrum of sustainable architecture philosophies; the ongoing practice of Morphosis allocates on the eco-technological end. Morphosis, represented by the work of Tom Mayne, did not explicitly start as a deep green practice. Morphosis departed from the formal exploration inquiry. Nevertheless, the incorporation of contradiction, change, intuition and dynamism in the design work is well aligned with the eco-principles that current environmental challenges demand.

The evolution of Morphosis work demonstrates the potential of ecological inspiration for building practices. The San Francisco Federal Building is an example of an ecologically driven practice. Design goals included energy efficiency and creation of occupant-friendly spaces [8].

SAN FRANCISCO FEDERAL BUILDING

The San Francisco Federal Building is one of the most important projects linking ecological responsibility and smart engineering systems. This building designed by Morphosis, architecture firm represented by the work of Tom Mayne (Pritzer Prize, 2005) [9]. The team was composed of a multidisciplinary group of professionals and consultants that combined efforts to create an ecologically sound building. The team included by Morphosis, Ove Arup and Partners, Smith Group, Lawrence Berkeley National Laboratory, Horton Lees Brogden Lighting Design, and Thorburn Associates and others.

The San Francisco Federal Building is an example of an ecologically driven practice. The design was oriented by clear targets and evaluated in terms of building long-term performance. The building's iconic presence represents a progressive prototype embodying green performance and aesthetic integrity [10].

The SFO Federal Building, contracted by General Services Administration (GSA), was conceived as a high performance response to the functional needs of the client. It is a clear technological statement where environmental considerations guided the process. The importance of this building lies in the impact that the project had on the ongoing research in fields such as building science, simulation and building information modeling (BIM).

SFO Federal Building is 240-foot-tall with 18 floors. The functional program required special considerations due to the use of the building (Federal Court). Given the activities that take place in a courthouse, both security levels and activity flows determined the zoning and location of different areas.

The building mass is divided in two volumes: the 5 story courthouse space for the use of special areas related to courthouse activities and the 18 story tower for complementary courthouse spaces, administrative areas and offices. The 5 story volume is mechanically ventilated while the 13 upper floors of the tower rely on a mixed ventilation mode for cooling.

Sustainability goals set at the design stage were focused on the creation of a clean and energy efficiency building with a comfortable indoor environment. The strategies employed to achieve such objectives were use of natural ventilation and daylighting, reduction of embodied energy in materials, site, orientation and massing.

The advanced engineering systems that were used to achieve adequate indoor environment demanded a multidisciplinary work force to integrate smart technologies and intelligent systems. Eco-technology became the architecture language for innovation. Therefore, the first consideration in the design process was identifying the appropriate means to achieve high performance in a more efficient way.

SFO Federal building is the result of a deep understanding of site and location. SFO's mild climate enables the use of natural ventilation. Given the location, there was great potential for the use of natural ventilation to achieve adequate indoor environment quality. The team paid special attention to the design of the façade as a key element for natural ventilation [11].

The façade was conceived as the thermal envelope. The final design of the façade is based on Computer Fluid Dynamics (CFD) [12] and other simulation studies [13]. Outdoor air is used to ventilate the internal spaces of the perimeter. Occupants have a certain degree of individual control of the facade system. The façade of the naturally ventilated portion of the tower is divided into panes that respond to different ventilation scenarios. The windowpanes of every floor are divided into five types of elements: fixed, automatic, manual, finned tube radiator and trickle vent.

The Building Automation System (BAS) plays an essential role in the facility's function. It monitors all the mechanical systems, including lighting and environmental conditions. It opens and closes different components of the façade system. At night, the BAS opens the windows to eliminate heat. It allows the pass of night air to cool the building's concrete interior. During daytime, the cooled thermal mass of the exposed concrete columns, shear walls, and wave-form ceilings provide comfortable conditions to occupants.

It is important to remark that the natural ventilation strategy involved an integrated design of façade, structure, ceilings and floor-to-floor height. It also determined decisions related to material choice and the shape of different elements of the building (structure, ceilings and windows). In a broader scale, the orientation and massing of the building was chosen to enhance internal wind flow. This strategy required a holistic view of the building as an organism where multiple dynamics occur at different levels.

The building code and construction standards only permitted a hybrid ventilation strategy. Spaces with a more restricted range of indoor conditions were located in the core to control their characteristics. A Variable air volume (VAV) system is used for the mechanically ventilated spaces. This mixed mode ventilation system strategy resulted in a 33 percent reduction of the operational energy consumption and associated CO2 emissions compared to similar office buildings designed to comply with California's Energy Code Tittle 24.

Another means to reduce the eco-impact of the building was the reduction of embodied energy of concrete. Half of the portland cement in the exposed-reinforced-concrete structure was replaced with blast furnace slag. The use of this by-product of steel prevented the release of approximately 5,000 tons of CO2.

ECOLOGICAL DESIGN PROCESS

The key concepts that guided the work of the design team were system, process, function and goal. Clear targets were established early in the design stage in order to clarify the role of different disciplines in the final result. This coherent multidisciplinary approach enhanced the efficiency and the final product.

The provocative exploration of shape, the main driver of Morphosis design practice is combined with environmental commitment. Green architecture is developed as a matter of ethics. The design was not based on simple intuition or formal exploration. It was supported by performance techniques and smart engineering systems. Building science was a key factor in conveying the ecological ideas. The uniqueness of every project requires different solutions. Genius loci[1] should dictate organization, materials, shape and other design considerations.

The design team considered the project as a living organism. The target 'Energy efficiency' implied the analysis of several factors: environment (daylight, wind patters, sun); human (occupant's comfort, space requirements); technical (structure, acoustics, thermal comfort). Since the building systems and subsystems were analysed together as an organism, the team was

[1] Genius loci refers to the particularities of a place; the special characteristics that make a place unique 'spirit of the place'

able to work for the reduction of energy consumption and the optimization of strategies to achieve the common goals.

It is important to remark that even though the building is Silver LEED; the certification was never an explicit intention of the team. This approach is more coherent in determining realistic and meaningful goals to achieve a more sustainable product. The team goal was not aiming to achieve certain level of certification; so they were able to determine specific targets related to the case. They were not constrained or biased to implement certain strategies. The team was eager to explore and understand the most preferable means to achieve the overall goals (a clean and efficient product, worker friendly spaces and connection to the community).

SUSTAINABILITY AS ARCHITECTURE DRIVER

The built environment should be regarded as an extension of natural systems. Buildings must be considered in their whole dimension. Buildings should not be separated from their contexts. They are not just artificial elements that provide spaces for human activities. They are habitats and shelters where human life takes place.

The use of technology as a means to dominate nature should be replaced by an ecological rationale to harmonize the relationship between human beings and nature. Concepts such as eco-communities and eco-technology must orient new developments, projects and refurbishments. AEC practice is facing a great creative era. Technology and science offer several opportunities to re-invent the future in terms that are socially and ecologically responsible.

The ecological debate should be questioned and clarified. Sustainable philosophy in architecture regards building processes as complex relationships of parameters. The multiple dynamics between a building and the environment act in different ways depending on the scale of the analysis. This organicist framework acknowledges the importance of learning from nature when designing buildings.

The old mechanical view of built environment as a giant mechanism composed of machinelike pieces is being replaced by new concepts. More than simple products, buildings are processes where synergies take place. Built and natural environment interact in different scales (global scale, immediate context, whole building, building components).

Given the complex interaction of components, building can be compared to puzzles. In order to complete the 'whole' you should analyse the pieces as an individual entities, both as part of a group and as part of the whole. In this analogy, the first level would set of components (façade, structure). These basic groups are the result of the summation of interdependent 'pieces' (wall, window, column). The second level corresponds to whole building. Now, ecological thinking requires additional layers of analysis: the interaction between building and nature (immediate context and global scale –broader analysis).

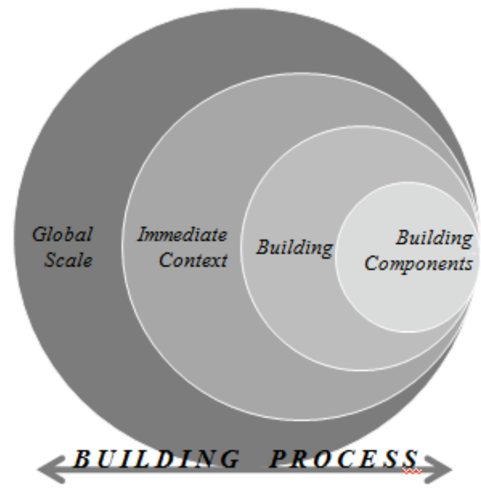

Figure2. Holarchy and different scales of environmental assessment

1. Global scale (macroscale): the ecological situation of the planet as a whole is relevant when assessing built environment (global water scarcity, emissions to atmosphere, GHG, ozone layer depletion). At this level, societies are considered as eco debtors or eco creditors.

2. Immediate boundary (microscale, region/context): the ecological impact of building is related to the site and their immediate surroundings (disturbance and impact on the proximity of the building location).

3. Whole building level: ecological impact is correlated to the dynamics between building components, building use and lifespan.

4. Building components: ecological impact depends on product choice without referring to the context of use, duration of use or lifespan (material)

The definition of sustainability should be re-framed using a holistic perspective. Mayrns explains the concept of the holistic view*"Organicism is best characterized by the dual belief in the importance of considering the organism as a whole and at the same time the firm conviction that this wholeness is not to be considered something myteriously closed to analysis but that it* *should be studied and analyzed by choosing the right level of analysis"* [14].

Sustainability in architecture cannot be limited to certification of buildings or labelling of green products. The proper strategies involve an overall analysis of the interaction between building and environment, considering scenarios of extraction, construction, operation and demolition. The lifecycle of the building provides a more comprehensive picture of how the building is acting toward the environment that it changes.

In the case of the San Francisco Federal Building, the team looked at the different scales of analysis in order to determine how to achieve specific targets. Energy efficiency as a sustainable strategy involved the choice of overall design of the building: material, shape, building envelope, orientation, massing, site and location.

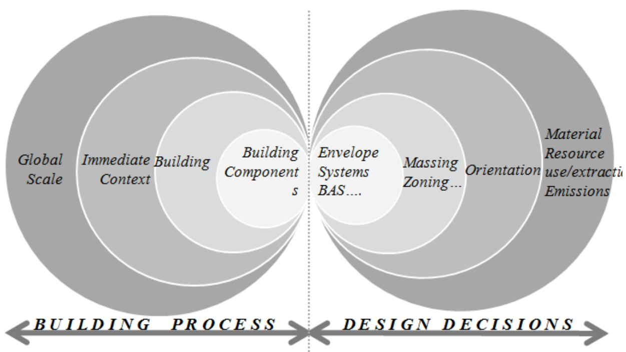

Figure3. Building and environment: scales of analysis and design responses

HOLISTIC ARCHITECTURAL APPROACH

The holistic approach involves the critical awareness of the different levels of a building's complexity. Buildings interact with the place where they are located (building-site). Buildings can be analyzed as a whole (building systems and subsystems). Buildings can also be regarded as the aggregation of individual but interdependent components (assemblies and subassemblies).

Dynamics that take place in buildings at different levels within components or with nature systems change depending on the lifespan of the building. In the construction phase, there are several flows related to use of materials, extraction and waste. During operation, the flows are meant to support the activities within the building. In terms of resource consumption, energy and water are the main aspects. Energy use is strongly correlated to pollution and emissions.

The drivers of green practices should be clearly stated. The main focus should be environmental stewardship. Such protection requires reduction of eco-impact. Sustainable architecture should consider the rational allocation of resources. Building practices should be developed under the premise that the satisfaction of human needs involves the protection of natural systems. Deep ecological and nature oriented philosophies constitute great assets for a critical architectural discourse.

The main shortcome of building practices is that the environment has not been the core driver of the sustainability agenda. The ongoing debate in the building industry needs to consider the importance of green considerations. The ecological movement in architecture has raised the discussion of what is acceptable in building practices and what should be achieved. Multiple initiatives aim to encourage a shift in the way that buildings are designed. Green building practices should be truly committed to reflecting the society vision of a more sustainable future.

Sustainable architecture includes functional, aesthetic, performance and ecological aspects. The ecological architecture thinking demands to question the ways architecture is made. Mitchell suggests that m*any of the common ways of thinking about the issue of sustainability, and architectural responses to it, are not radical enough. Perhaps our assumptions and ideas need to be rethought…. As discussions unfold, (it is needed) to think broadly and adventurously…. To redefine our basic conceptions of what architecture is* [15].

Ecology and architecture make strange, but star crossed, bedfellows [16]. However, buildings can be designed, built and operated in ways that are environmentally responsible. The key aspect is to realize how creative practices of ecological architecture *construct and enable alternative forms of relationship and hybridization between people, place, material and Earth* [26]. Initiatives encouraging green practices and sustainable practices themselves play a major role in achiving the sustainable vision of the future that society demands.

CONCLUSIONS

Despite the breadth of ecological knowledge, best building practices and technology that is available; architecture practices have been somehow negligent when designing, building and operating buildings. The paradigm shift from 'buildings-as-machines' to 'buildings-as-organisms' raises consciousness about the interdependence of man made and natural systems.

Building practices should be aiming to achieve specific goals that can be evaluated in terms of quantitative and qualitative improvements. The drivers of the ecological agenda should be related to a broad set of objectives reflecting society's vision of sustainability. Sustainability is a fuzzy term that needs to be clarified when applied to a specific context. If the term is not clearly defined, sustainability could be interpreted in ways that do not contribute to critical discussions of environmental processes in the building industry.

Sustainability is a blurry term that mixes economic, social and environmental aspects. Unfortunately, the environment has been neglected. Society is not fully aware of the limitations of resources that human beings count on. Building practices are mostly determined by business/profit oriented thinking where economic aspects rule over other considerations. Environmental problems are global issues and only few have taken stewardship of the environment. The situation will change when society realizes that resources are not unlimited. Then, the building industry will have to move from green high performing attempts to real sustainable exercises. Clear and transparent targets should be considered in order to control, mitigate and even remediate the stress on the environment. Societies with more consciousness about environmental issues are more demanding in what they expect from building performance.

Sustainable building practices should be oriented by clear targets that express the society's vision of a sustainable future. The evaluation should be performance based in order to link specific sustainable goals and quantify the success of the outcomes. The criterion requirements should express the objectives that society looks for in terms of sustainable future. A value system should be the guiding principle of building practices. Society and environment are integrated as one hollarchic interdependent whole.

Building aspects should be related to ecoimpacts. This top to down approach requires the clarification of the type of impacts and the levels of building assessment. Design process/products or deliverables should be assessed in terms of ecological impact and environmental performance. The rationale behind criteria should be related to the value system of the context to be applied. Practices should aim to be more performance driven to be environmentally conscious. Performance requires thinking in terms of ends instad of means. The key issue in performance is outcomes.

The current challenge for architectural practices is combining innovation with ecological respect. In the context of technological promises for a sustainable future it is important to question how such innovations could be applied as a means to achieve specific goals. The use of high engineering systems supported by adequate studies and on a case by case basis will give opportunities to achieve sustainability.

REFERENCES

1. Wilson, S., (2002). *Information Arts: Intersection of Art, Science and Technology*, MIT Press: pp. 129

2. Serlin, D., (2002) *Big and Green: Toward Sustainable Architecture in the 21st Century,* Princeton Architecture Press: pp. 147

3. Wines, J., (2000) *Green Architecture: Nature's Revenge: A Brief Survey of the 20th Century Green History*, Taschen Press: pp. 16

4. Luke, T., (2000) *Ecocritique: Contesting the Politics of Nature, Economy and Culture*, Minnesota Press: pp. 180,

5. McDonough, W., Braungart, M., (2002) *Cradle to Cradle: A Question of Design*, North Point Press: pp.24

6. Hough, M., (1995) *Cities and Natural Process*, Routledge Press: pp. 27

7. Orr, D., (1996) *Ecological Literacy*, SUNY Press: pp. 24

8.Tom Mayne, San Francisco Federal Building Http://archrecord.construction.com/features/interviews/0711thommayne/0711thommayne-1.asp [14 December 2008]

9. Tom Mayne, [Online], Available: http://www.pritzkerprize.com/laureates/2005/index.html [10 October 2008]

10. Tom Mayne on Green Design, [Online], Available: http://archrecord.construction.com/features/interviews/011thommayne/0711thommayne-1.asp [14 December 2008]

11. Littlejohn, D., (2007). *The sate of Mayne's New Federal Office Building*. Wall Street Journal (Eastern edition) New York, NY Nov 15: pg. D-7

12. Carrilho da Graca, G., Linden, P.F., (2003) Simplified modeling of cross-ventilation airflow. In *ASHRAE Transactions* 109.

13. Carrilho da Graca, G., Linden P.F., McConahey E. and Haves P. (2003) Design and control of low energy cooling strategies for a large, naturally ventilated office building. In *Building Simulation IBPSA*, Eindhoven, Netherlands.

14. Wilson, S., (2002). *Information Arts: Intersection of Art, Science and Technology*, MIT Press: pp. 129

15. Mitchell, W., (1998) *Dimensions of Sustainability: Dematerialization, Demobilization and Adaptation,* E&FN SPON Press: pp. 7

16. Ingersoll, Richard, (1996) *Second Nature: On the Social Bond of Ecology and Architecture*, Chapter 3, T. Dutton and LH Mann, eds., Reconstructing Architecture, Minnesota Press: pp. 119-157

26. Corner, James, (1997). *Ecological Design and Planning*, eds. G. Thompson and F. Steiner, Wiley Academy: pp. 105