Design Parameters and Initiatives for Ecological and Green Design in Interior Architecture

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Abstract: - This study aims to discuss the ecological and green design concepts in interior spaces. The role and the contribution of interior spaces and interior architecture to the ecological and green design will be output. Ecological and green design implementations will be figured out in the built environments. Contribution of interior architecture and interior design of the buildings to those concepts will be discussed. Energy and emissions in interior spaces with lighting, ventilation, air conditioning thermal comfort, insulation and interior design material, material selections, material applications and surface treatments systems in interiors will be introduced and their contribution to the building sector from ecological and green design approach will be discussed.

Key-Words: - Ecological, Green, Design, Materials, Energy, Lighting, Interior Space.

1 Introduction

The concept of ecological and green design is one of the most frequent discussed subjects in the related fields with the build environment. The importance of the subject is increasing everyday; while the world population is increasing and the overall quantity of natural resources is decreasing [3, 4]. The conflict of this century is an increase in peoples' life quality while a decrease in the overall consumption of natural resources. Ecological and green design ideologies are significant titles that are directly related in within the concept of sustainability in the built environments. It is estimated that the world's population will almost double from the present 6.2 billion to around 8 to 10 billion by 2025 and as a consequence, will increase both the demand on resources as well as the environmental impact resulting from human activities. Since the earth is a closed ecosystem, it will not be possible to support such an exponentially increasing population within the traditional growth-oriented economic models [9].

Therefore, a shift in the current economic and socio-cultural framework is required: a transition from a traditional material and product paradigm to an emerging knowledge and service paradigm; a transition in which the research into sustainability shifts from a technological and product related innovation process to a broader techno-socio-cultural process [8].

On the other hand the built environments and the construction sector is the area which uses an important amount of energy and materials that are produced by world resources. Working Group of Sustainable Construction (WGSC) (2004), determined that 50% of the energy and the materials that are produced with world resources are used by the building sector in the world. If we consider the case in Turkey, Energy Consumption Report of European Union implies that 31% of the produced energy is used by the building sector [15]

Interior Architecture and interior design discipline has an important role in construction and built environment sector to provide contribution to the ecological and green design concepts. This study aims to evaluate the ecological and green design concepts within the built environment discipline. Ecological and green design approaches in interior spaces will be discussed. Energy and emissions in interior spaces with lighting, ventilation, air conditioning thermal comfort, insulation, finishing materials and the surface treatment systems and their contributions to the concept of ecological and green will be overviewed.

2 Concept of Ecologic and Green Design

The concept of ecological design in the sector of construction is defined as; "the creation and responsible management of a healthy built environment, based on the efficient use of resources and on ecological principles" by Scott in 1999 [13]. Ecological and Green design in the construction industry works for the present and future improvement in the life quality [7].

This requires the characterization of materials from an ecological point of view, a complex operation under the conditions in which the environmental impact of building materials is difficult to assess, mainly due to the numerous different problems to be taken into consideration and to the fact that the data available are frequently inadequate for an accurate evaluation [16].

Basic principles that underlie ecological and green design in construction industry can be listed as:

1. Saving of existing material resources;
2. Maintenance of a clean and healthy environment both in terms of topographic changes and the degree of air, water and soil pollution;
3. Reduction of the embodied energy in buildings;
4. Measures regarding the diminution of heat losses;
5. Provides an optimal ratio between the surface of the envelope and the building volume;
6. Contributes the thermal insulation of the closing elements of a building (exterior walls, floors, roofs);
7. Ensuring of adequate thermal inertia;
8. Contributes the creation of insulating spaces between environments with different temperatures (buffer spaces in attics, basements, staircases, etc.);
9. Requires more efficient installations and equipments;
10. Provides hierarchy of spaces requiring different temperatures and their orientation in relation to the cardinal points;
11. Requires use of renewable energy sources (solar, geothermal energy);
12. Provides optimization of natural ventilation;
13. Encouragement of investments for the conservation of energy;
14. Provides and increased awareness of users, adoption of more rational building operation conditions [7].

Briefly ecological and green design can be defined as; any form of design that minimizes environmentally destructive impacts by emulating and integrating with natural ecosystems can be referred to as eco-design [8]. As such, eco-design seeks to provide a framework for an environmentally appropriate system of design and management by incorporating both anthropogenic and ecological values, at relevant spatial and temporal scales. The concept of ecological design involves several key aspects in the study of Yang, Freedman, and Cote (2004) [16].

Meet the inherent needs of humans.

Humans and the human economies cannot exist without using natural resources as sources of food, materials, manufactured products, and energy. By using those natural resources some degree of environmental damage is caused by the human economy. The main aim of ecological and green design is to meet the ecological sustainability, by finding ways of manufacturing goods, constructing buildings, and planning more complex enterprises, such as business and industrial parks, while reducing resource consumption and avoiding ecological damage to an acceptable degree [16].

Move toward resource sustainability.

Sustainability in human economy essentially should be based on the wise use of renewable resources, which are capable of regenerating after harvesting and can potentially be available for many generations. In contrast, non-renewable resources are diminished by use; although they can contribute to economic growth, they cannot be used as the primary basis of a sustainable economy. These principles can be applied to the design and operation of buildings and cities, the manufacturing of goods, and other economic activities [16,17].

Maintain ecological integrity.

Mainly ecosystems are life systems that support biodiversity and natural communities, while also providing critical support for the human enterprise. Maintenance of the integrity of ecosystems must be considered a key element of economic sustainability. As such, a purpose of eco-design is to integrate human activities with the structure and dynamics of natural flows and cycles of materials, organisms, and energy. This begins with development of an understanding of the ecological context of particular design problems, and then developing solutions consistent with that circumstance [16].

Emulate natural ecosystems.

Natural ecosystems are characterized by complex patterns and dynamics of biodiversity, materials, and energy, occurring at various spatial and temporal scales. These patterns reflect the long- and short-term influences of biological evolution (including speciation and extinction), disturbance and succession regimes, environmental change (i.e., in climate), species introductions, and anthropogenic influences associated with pollution and other stressors. A central goal of eco-design is to emulate these natural ecological qualities when planning for anthropogenic activities, so the resulting effects will be relatively "natural" [16,17].

Eliminate natural debt.

Environmental economics is an alternative way of looking at these complex systems, involving the full costing of resource depletion and environmental damage. As such, eco-design seeks to comprehensively account for all of the costs and environmental implications of alternative choices of design. It considers a wide range of environmental impacts in a holistic manner, over the entire life-cycle of the project, from the extraction of natural resources, through manufacturing of components, to construction and operation, and finally deconstruction, re-use, recycling, and disposal of components [16].

Protect natural habitat.

It is important to consider whether the ecological risks should be offset by designating protected areas that are not used intensively by humans, and are intended to sustain species and natural ecosystems that are incompatible with the proposed project or with the human economy in general [16].

Increase environmental literacy.

Environmental protection is a broad societal responsibility. Eco-design is the work not only of experts, but of entire communities—it entails deep cooperation among designers, government, businesses, and citizens. This can influence the kinds of architecture and community that they prefer and advocate to politicians and businesses. As such, when eco-designers begin to design a community, they must first establish the degree of environmental protection that is achievable—there must then be agreement among government, businesses, and the populace on such key questions as the degree of protection of natural habitat and the amount of investment in pollution control [16,17].

The principles of ecological design can be applied within a continuum of spatial scales, ranging from individual homes, to neighborhoods and industrial parks, as well as to particular manufactured products [9].

Ecological and green design can be applied to both the improvement of existing urban areas and communities, as well as planning for new ones. Improvements of existing areas begin with the identification of such environmental problems as inefficiencies of use of materials and energy environmental pollution, and conflicts with indigenous biodiversity, followed by efforts at mitigation and restoration ecology [7].

Ecological and green design has the potential for developing environmental synergies through the coordination of economic activities among commercial or industrial enterprises. A key aspect of this design is the development of a web of enterprises connected to form an efficient and inter-dependent system, in which discarded materials and heat of processes are used as inputs to others [8].

Ecological and green design can also provide to minimize the use of land, conserve heat in winter and cool in summer, reduce emissions of pollutants, and naturalize the landscaping. The use of land can be optimized by designing multi-storied buildings instead of sprawling ones, and by efficiently allocating internal energy use can be decreased by using passive and active solar heating technologies in winter, shading and reflecting surfaces in summer, and efficient insulation, windows, lights, and appliances; externally, trees can be positioned to provide shade in summer and wind-shielding in winter; in some cases, low-grade "waste" heat from thermal power plants can be used in nearby buildings [17].

Building materials and furniture can be selected to be efficiently manufactured (in terms of the consumption of energy and material) from renewable resources, to be long-lasting yet readily reused or recycled, and to not emit indoor pollutants [9].

Locally traditional (or vernacular) design elements can be incorporated into buildings to improve their energy and material efficiency, aesthetics, and comfort, while also respecting cultural heritage. Emissions of wastes can be reduced [8].

Landscaping can be naturalized by utilizing only native plants in horticulture, and by designing to simulate natural communities appropriate to local conditions, while respecting the need for pleasant aesthetics and low-impact recreational use [7].

Ecological and green design has been applied extensively to the development and manufacturing of certain products. With continuing increases in the human population and in industrial production and consumption, concerns have been raised about the environmental burdens associated with the extraction and harvesting of materials, the manufacturing of products, the use of the products and finally their recycling or disposal. Within this context, eco-design is recognized as a strategy that can be applied to reduce the impacts associated with the production and consumption of products [17].

Consequently interior architecture as a discipline, controls most of the above mentioned parameters in the design of interior spaces. Interior architecture has a great potential to control and direct the ecological and green design parameters in interiors.

3 Ecologic and Green Approaches in Interior Spaces

In the concept of ecological and green design in built environments, interior spaces have a great significance as they are the main shelters of the individuals [2]. Using the basic concepts of ecological and green design requirements interiors will have a great contribution the concept of sustainability. Energy and emissions in interior spaces with lighting, ventilation, air conditioning thermal comfort, insulation ,interior finishing material selections and the interior surface applications like green walls can make a great contribution to the interiors, occupants and the sustainability as well (Fig:1, Fig:2).

Fig: 1: Ecological Interior

Fig: 2: Ecological and Green Interior

One of the important role in the construction of buildings is played by the choice of materials based on criteria that should meet several requirements. These must ensure throughout the life cycle duration of the building the reduction of the harmful effects on the surrounding environment. In this sense, a number of factors for the evaluation of building materials should be considered the life cycle of materials is the energy consumed in technological processes and transport. The exhaustion of natural resources, the impact of topographic changes on the environment due to extraction processes and waste resulting from the various life stages of the products, the pollutants emitted during some processes are factors that should be considered in the choice of the optimal building material for a construction with a well established use [2]. Criterion of resources, criterion of topographic change, criterion of waste and recycling, criterion of pollution, energy criterion, biological criterion of interior spaces should be considered during the design stages of the interior architecture projects [11].

4 Energy and Emission in Interior Spaces

Buildings use great amount of energies in interior spaces for lighting, heating, cooling ventilating air conditioning and so on. Energy consumptions of the buildings for those activities should be controlled by the designers. Greenhouse gas emissions in interior spaces are directly related to energy consumption. Integrated Energy Approach Greenhouse reductions are achieved in a staged approach. Reduction in overall energy consumption through demand reduction and energy efficiency

should be considered. Reduction in electricity and gas utility consumption by utilizing waste products and renewable energy technologies should be aware of. Lighting, heating, ventilating, air conditionings and insulation are important design parameters in the ecological and green interiors [2,3].

4.1. Lighting in Interiors

Day lighting is essential in architectural and services design. To allow maximum daylight penetration into a building while minimizing heat gain and thereby reducing indoor lighting loads. Day lighting strategies combined with dimmable lighting systems would allow high control of indoor lighting levels while minimizing power consumption for the buildings [3].

Size and location of the existing windows facilitate are important in the interior design. High level of daylight harvesting for the buildings, may not be feasible to add new windows without influencing the heritage nature of this building. A high level of architectural input in regards to design, orientation and external shading is required to effectively maximize daylight potential (Fig:3) [3].

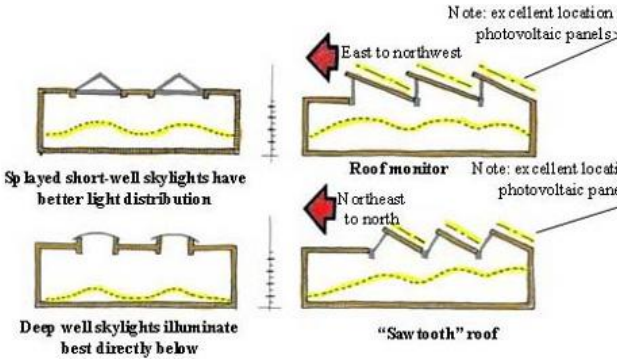

Fig 3: Different type of openings and the illumination levels provided.

An efficient lighting design and control strategy would reduce artificial lighting energy consumption and allow maximum advantage to be taken of daylight. Lighting power density will be required to meet the occupant's requirements. Efficient light fittings such as fluorescent lamps or compact fluorescent lights can be used in interiors. Low-power LED lamps can be an alternative in feature lighting with good colour temperature control. Daylight dimming of external and streetscape perimeter lighting, as well as internal lighting adjacent to windows can be used. Efficiency can b increase by using controls including timers and motions sensors in infrequently used areas [3,5].

Energy consumption from external lighting should be controlled as well. The light source of the external lighting fixtures should be controlled. The luminance levels of the outdoor spaces should be controlled and the unnecessary high illuminated areas should be restricted. External lights can be connected to daylight sensors and daylight sensors can be combined with a time switch to reduce the energy and emission loss [5].

4.2. Heating, Ventilation & Air-Conditioning in Interiors

Heating, ventilation and air conditioning in interior spaces are another important energy consumption parameter. Natural ventilation and air change effectiveness is an important concept in the interior architecture. The cross ventilation system proposed relies on cooled filtered air being provided by surrounding vegetation and landscaping. This cooled and filtered area is then drawn through the apartments via convection. The facade openings would be small, top-hung and set low in sets of two or three to draw in the low lying cooler air. Purpose designed vents, high level louvers, or ventilating skylights can be used to exhaust warm air at the top of the spaces, creating outlets for the thermal flues that are formed by the stairwells, thermal chimneys or centralised ducts. Surrounding vegetation would improve the effect of natural ventilation especially during summer time (Fig:4) [3].

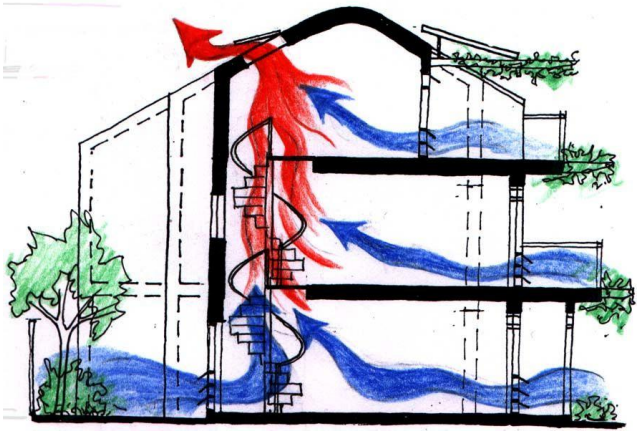

Fig 4: Natural ventilation

Natural Ventilation should be considered a priority over wind energy. Natural ventilation systems rely on pressure differences to move fresh air through buildings. The pressure differences can be caused by the buoyancy effect created by temperature differences, by wind, or by differences in humidity. Natural ventilation systems are circuits,

equal importance must be given to both air supply and exhaust [3].

Natural ventilation, unlike fan-forced ventilation, uses the natural forces of wind and buoyancy to deliver fresh air into buildings. Fresh air is required in buildings to alleviate odors, to provide oxygen, and to maintain thermal comfort. At interior air velocities of 160 feet per minute (fpm), the perceived interior temperature can be reduced by as much as 5°F. However, unlike true air-conditioning, natural ventilation is ineffective at reducing the humidity of incoming air. This places a limit on the application of natural ventilation in humid climates [3] (Fig: 5).

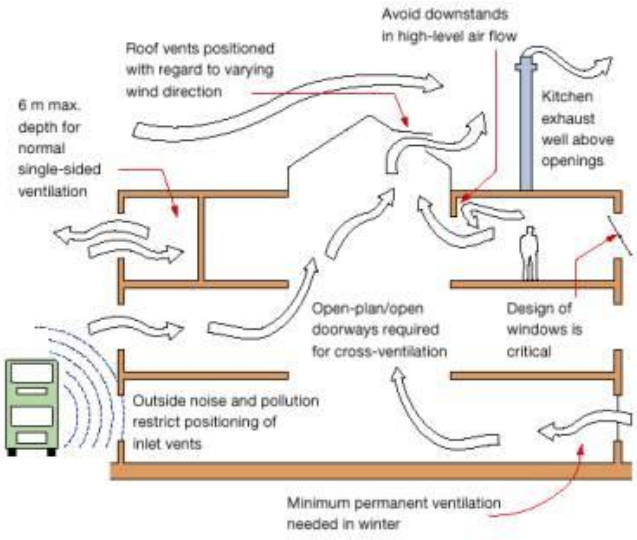

Fig 5: Natural ventilation

Heating and cooling of the building will make up a large proportion of the building's energy use throughout the year. Several options for the HVAC systems will be investigated. The layout and type of the development will allows either a localized package or split unit design, or a centralised energy plant design where the thermal energy is generated centrally and then distributed around the development. The efficiency of the system, capabilities of the system as well as expected installation and operation cost should be considered. Heating and cooling demands of the building vary with the functions of the interior spaces. Different occupancy rates, types of activity and other factor such as equipment loads will affect the necessary levels of heating and cooling. The different spaces, functions and the occupant's should be considered in order to accurately estimate the heating and cooling demands of the building system [2,3].

4.3. Insulation

Insulation reduces the heat transfer between the internal and external conditions. Adequate insulation in the ceiling and walls would reduce the heating and cooling load of the buildings and would reduce the ongoing operational costs. This has a twofold saving through a smaller mechanical system capacity along with operating energy consumption reduction (Fig: 6) [3].

Fig 6: Heat Loss of a building.

Glazing and Window Framing Double hung timber frame windows would be installed to reduce heating and cooling energy consumption and maintaining occupant comfort through natural ventilation. Visible Light Transmission (VLT) is the percentage of visible light transmitted by the glass. Shading Coefficient (SC) is the percentage of solar radiation that is transmitted through the glass. U-Value is a measure of how much heat is passed through the glass. Selecting glazing with a low SC will help to avoid heat gains in the summer, while glazing with a low U value reduces losses in the winter through the glass. Incorporating effective shading features into the design can avoid the necessity for low shading coefficients in the glass, which usually also decrease the VLT of the glass. To maximise the natural daylight within the buildings, VLT would be as high as possible. Thermal comfort index and PMV (Predicted Mean Vote) should be considered at the design stage to meet the requirements for each individual building [3].

5. Interior Finishing Maternal

Materials and design are always be very ecological and green interior spaces. The selection of material for certain product is of vital importance, while the material determines the use of our natural resources as well as the amount of energy used for the production and the use of the product [10].

Selection of material is traditionally made by technical demands like price, strength of material, temperature stability, density and hardness. The selection of material for certain product is of vital importance, while the material determines the use of our natural resources as well as the amount of energy used for the production and the use of the product. Selection of material is traditionally made by technical demands like price, strength of material, temperature stability, density and hardness [10].

Essential of the choice of building materials for ecological and green design starts from an analysis of the design theme regarding the use of the building, its expected life duration, the loads to which the building will be subjected and the thermal comfort requirements to be met, the choice of the building materials will have to take into consideration the following synthetic criteria (Fig: 7, Fig: 8, Fig: 9, Fig:10) [1,17].

Fig 7: Natural materials used as interior finishing material

Criteria	Characteristics
Ecological	Embodied energy
	Percentage of waste reuse
	Percentage of waste reprocessing
	Percentage of use as earth filling
	Percentage of ultimate waste
	Fuel consumption during transport per t·km
Thermal Comfort	Specific heat
	Thermal conductivity
	Thermal diffusivity
	Factor of vapor permeability resistance
Mechanical Strengths	Compressive strength
	Bending strength
	Tensile strength
Cost	Price

Fig 8: Synthetic Criteria and Characteristics of Interior Finishing Materials [1].

Fig 9: Natural materials used as interior finishing material

Fig 10: Natural materials used as interior finishing material

Interior finishing materials are essential in interior architecture. The selection of interior finishing materials makes a great contribution to the concepts of ecological and green design. Choose of abundant, non-toxic materials and familiar to the nature is essential (Fig: 11, Fig: 12) [5, 17].

Fig 11: Natural materials used as interior finishing material

Fig 12: Natural materials used as interior finishing material

Avoidance of ecologically sensitive products is important. Selection of materials with a low embodied energy and high recycled content can be used. Low toxicity material, low impact on the indoor environment, durability, flexibility and recyclability of the interior finishing materials are important for ecological and green interiors. Emissions in manufacture and composition, including greenhouse gases and ozone depleting substances should be considered. On the other hand the utilising prefabricated construction can minimise construction work and waste on site (Fig: 13) [6].

Fig 13: Natural materials used as interior finishing material

6. Interior Surface Treatments

Floors, wall, ceiling surfaces are the main working areas in the design of interior spaces. Ecological and green design in interior surface can be achieve by working with those surfaces. Green walls and green ceilings can be designed by using four different type of surface applications (Fig: 14) [5].

Fig 14: Green wall applications in interiors.

6.1. Type 1 Green Surface System

Type 1 system is considered as the most versatile interior system. By using industry standard pots, it is easily maintained and can have plants easily changed out for different seasons and special occasions. It can be installed on virtually any indoor surface. The system contains patent-pending recycled polypropylene trays that can fit any wall dimension and its waterproof. It has a tongue and groove waterproof backing along the entire back surface of the surface. Remote irrigation system is computerized vertical flow irrigation system that

allows for remote control, when installed with standard recirculation tanks. Recirculation tanks are stored below or behind the wall, these tanks can be topped up automatically when a water supply is available, or filled by hand [12,13,14] (Fig: 15)

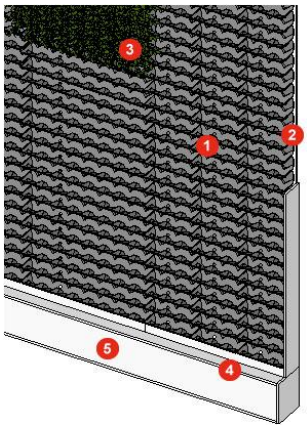

Fig. 15: Type 1 Surface System

6.2. Type 2 Green Surface System

Type 2 system is made up of a floating stainless steel planter (vine container) system that safely trains vines over a building facade. Containers can be customized to fit any design or size. Insulated container that can be heat-wire traced, ensures that from freezing shock in season changes It was designed for maintenance, the containers can either be mounted directly to a wall or on a maintenance catwalk in very high installation situations. Remote monitored irrigation and fertilization system is computerized vertical drip irrigation with temperature control. Wall mounting system is designed to be mounted on concrete, wood frame, steel beam, or on a catwalk system in very high situations [12,13,14] (Fig. 16).

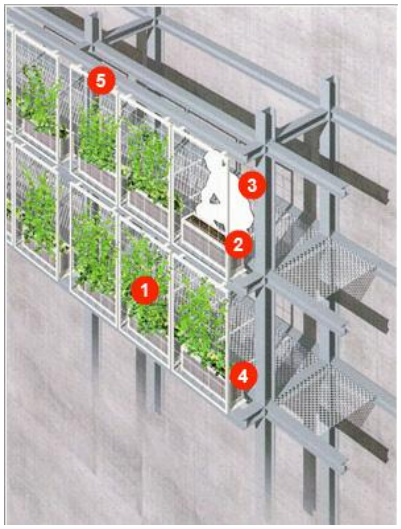

Fig. 16: Type 2 Surface System

6.3. Type 3 Green Surface System

This system is specified for indoor environments such as lobbies, reception areas, hallways and other places of high traffic. It is essential for quick and simple deployment. It includes fully integrated design that allows for placement anywhere, no need for a water connection. Irrigation tank and pump or water tank, pump and timer are integrated into the base of the system, can be filled by hand.. [12,13,14] (Fig: 17).

Fig. 17: Type 3 Surface System

6.4. Type4 Green Surface System

Type 4 system is flexible, modular system that can be installed on virtually any outdoor surface in any hot or cold climate, and is designed to resist heavy winds, wind drive rain and earthquakes [12,13,14]. Patent-pending panels are a meter square stainless steel that can be customized to fit any design or wall type. Non-soil structural growth medium is non-eroding to ensure plant longevity, and much lower maintenance than loose soil systems. Plants grown into the panels for several months before shipped to the site so that they will not blow away under strong winds or shake out of the panels under seismic activity. Remote irrigation and fertilization system is computerized vertical drip irrigation. [12,13,14] (Fig: 18).

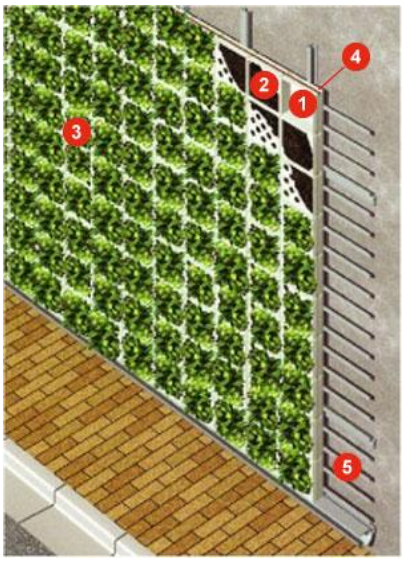

Fig. 18: Type 4 Surface System

7. Conclusion

Ecological green and sustainable designs are the important concepts in the changing and developing world considering the world resources and the world population. Interior architecture and interior design in the field of construction sector mainly should be developing some ecological green and sustainable approaches in their design field. In the concept of ecological and green design in built environments, interior spaces have a great significance as they are the main shelters of the individuals. Using the basic concepts of ecological and green design requirements interiors will have a great contribution the concept of sustainability. Interior finishing material selections and the interior surface applications like green walls can make a great contribution to the interiors, occupants and the sustainability as well.

With this study the ecological and green design concepts within the built environment discipline was evaluated. Ecological and green design approaches in interior spaces were discussed. The main contributions of the area with energy and emissions in interior spaces with lighting, ventilation, air conditioning thermal comfort and insulation in interiors and their contributions to the concept were determined. In addition, interior finishing materials and the surface treatment systems were overviewed in order to make a contribution to the interior design field from ecological and green design point.

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