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The Living walls as an Approach for a Healthy Urban Environment

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Abstract

Societies are in a need for making a conscious choice to switch to a more sustainable way of life. Design, construction, and maintenance of buildings have a tremendous impact on the environment and the natural resources. All around the world, a huge amount of buildings are being constructed with many more to be done. The challenge will be to build them smart with a minimal usage of non-renewable energy, minimal production of pollution, and minimal cost of energy dollars. Other important issues in building include increasing the comfort, health, and safety of people who live and work in them. Indeed, buildings consume many of the natural resources and are responsible for many problems. Now, in the 21st century, people are slowly beginning to realize the necessity of green architecture where new aspects and technologies started to emerge in terms of green buildings such as green walls which are considered a new prospect for the phenomenon of urban heat island and energy conservation aspects [1,5].

This research will display the meanings, the advantages and the techniques of the living wall as a part of the sustainable strategy for the urban environment. The Green vertical surfaces can contribute significant environmental, social and economic benefits to the built environment. moreover the research will display why this emerging technology should be considered as a valuable part of the design process for addressing climate change and energy crisis.The living wall could also function for urban agriculture, urban gardening, or for its beauty as art. It is sometimes built indoors to help alleviate sick building syndrome. Living walls are particularly suitable for cities, as they allow good use of available vertical surface areas. They are also suitable in arid areas, as the circulating water on a vertical wall is less likely to evaporate than in horizontal gardens.

Finally, the research will conclude with several recommendations for the using of living walls technique which suits the arid climate as a part of sustainable strategy for the urban environment.

Bio walls, climatic change, vertical vegetations

1. Introduction

Throughout history greening of outside walls and roofs of buildings has taken place. Reasons for doing so were the increase of insulation (keep cool in summer and keep cold out in winter), improved aesthetics, improved indoor and outdoor climate, reduce the greenhouse gases such as Carbon Dioxide (CO2), Carbon Monoxide (CO) and Nitrogen Dioxide (NO2) as well as increasing ecological values by creating habitats for birds and insects.

Throughout the years, replacement of vegetated surfaces with paved and impervious surfaces in the urban area have caused the temperature in the area to increase comparing to the surrounding rural area. This is because the paved surfaces absorbs, retain, and reradiate more solar energy than grasses and trees. The ambient temperature in urban area can be as much as 6ºC warmer than the air in rural areas [5].

Egypt now is experiencing rapid economic growth especially in the last 5 or 6 decades Developments on urban areas have changed the surface profile of our cities. The skyline of a city are now complimented with tall buildings, condominiums and the surface area are covered with paved, roads and long stretch of highways which absorb, contain and reradiate more heat comparing to the past years. With these rapid developments and change of our surface profile, along come the environmental problems such as, drought, pollutions and the phenomena of urban heat island.

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1. Urban Heat Island

UHI is characterized by significantly higher air temperature in densely built environment as compared to rural temperatures (Figure 1.1). This is caused by the rapid urbanization and change of the land profile where more impervious surfaces such as asphalt, concrete and glass are found rather than grass or green area.

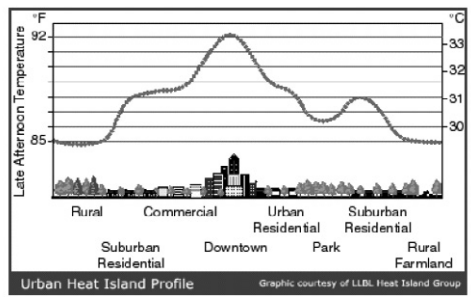

Figure 1. Diagram of an urban heat island profile [6]

1.1 Causes of Urban Heat Island

The UHI effect has been explored worldwide and from those studies, the cause of UHI can be summarized as below:

a) Canyon Geometry

Urban canyons, especially the deep ones, work as traps which decrease the loss of both short-wave and long wave radiation emitted from streets and building will eventually find their way into indoor space or re-emit back to the surroundings after sunset [2].

b) Building Materials

During the daytime, more sensible heat can be stored in building materials, such as concrete, brick and asphalt, due to their big heat capacity. The stored heat will then be released back to the environment at night.

c) Greenhouse Effect

Long-wave radiation can easily be trapped inside the polluted urban atmosphere due to the greenhouse effect.

d) Anthropogenic Heat Source

Anthropogenic heat generated from industrial combustion, traffic, air-conditioners and so on can aggravate the UHI effect.

e) Evaporative Cooling Source

The UHI effect can be mitigated by evaporative cooling means, such as vegetation, water body and so on, since more incident energy can be transformed into latent heat rather than sensible heat. Unfortunately, the lack of such evaporative cooling methods in cities, especially the loss of greenery, causes severe UHI effect.[2]

f) Wind Pattern

Heat trapped inside urban canyons can be adverted from source areas by turbulent transfer. However, such heat loss from within streets can be reduced where there is possible obstruction of wind flow by urban settings as shown in (Figure 2). In this case, ventilation in urban open space is of great importance.[1,2]

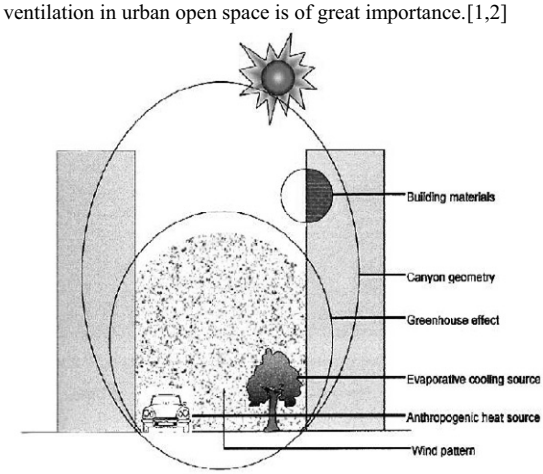

Figure 2. Diagram showing the most important factors that may influence the Severity of the UHI effect[3].

2. Green Walls

Green walls or also known as vertical greenery is actually introducing plants onto the building façade. Comparing to green roof, green walls can cover more exposed hard surfaces in the built environment where skyscrapers are the predominant building style [4].According to Ken Yeang (1998), if a skyscraper has a plant ratio of one to seven, then the façade area is equivalent to almost three times the area. So, if the building is covered two thirds of the façade, this have contributed to doubling the extend of vegetation on site. So a skyscraper can become green, thus increasing the organic mass on the site.[3]

2.1 Types of Green Walls

The green walls can be divided into three fundamental types according to the species of the plants; types of growing media and construction method (see Table 1).

Table 1. Comparison of three green walls methods [4]

Type	Plants	Growing media	Construction type
Wall-climbing	Climbing plants	Soil on the ground or in planted box	Minimal supporting structure is needed
Hanging-down	Plants with long hanging-down stem	Soil in planted box on every storey	Planted boxes and supporting structure should be built at according storey
Module	Short plants	Lightweight panel of growing media (such as compressed peat moss)	Supporting structure for hanging or placing modules should be built on facades

2.1.1 Wall-climbing Green wall

The wall-climbing type is the very common and traditional green walls method (see Figure 3). Although it is a time consuming process, climbing plants can cover the walls of building naturally. Sometimes they are grown upwards with the help of a trellis or other supporting systems.[3,4]

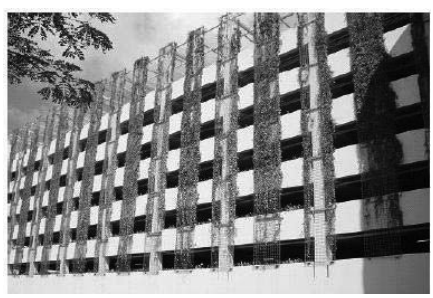

Figure 3. Example of Wall-Climbing green wall at Republic Polytechnic, Singapore

2.1.2 Hanging-down Green Wall

The hanging-down type is also another popular approach for green walls (see Figure 4). It can easily form a complete vertical green belt on a multi-storey building through planting at every storey compare to the wall-climbing type.[3]

2.1.3 Module Green Wall

The module type is the latest concept compared to the previous two types. It requires more complicated design and planning considerations before a vertical system can come to place (as shown in Figure 5,6). It is also probably the most expensive green walls method.[4]

Figure 5. Example of the module type green wall

Figure 6. The module used to plant the vegetation on the green walls

2.2 Benefits of green walls in the built Environment

Plants in a city can provide quantitative benefits, in the form of financial returns, as well as qualitative environmental, social and aesthetic benefits. Although the benefits are discussed separately, they are actually inseparable and should be appreciated in the built environment[5].

2.2.1 Environmental benefits

Plants can offer cooling benefits in the city through two mechanisms, direct shading and evaporate transpiration. The green walls used plants which provide shading to the building. It is very straightforward and is very much depends on the density of the plants in the green walls. As a result, not only the shaded building, but the ambience also will experience a relatively low temperature. The temperature reduction will not only affect the building, but also to the urban environment.
Plants, especially trees, have been widely believed to be effective scavengers of both gaseous and particulate pollutants from the atmosphere in the urban environment. They can improve the air quality by filtering out airborne particles in their leaves and branches as well as by absorbing gaseous pollutants through photosynthesis.[5,6]

By using green walls, limited spaces or lack of land is no longer a problem, as it covers the building façade, thus the air quality in the urban area with high rise and skyscrapers can also be improved.[7]

Storm water in the urban area is traditionally routed off impervious surfaces and transported in drainage-pipe systems to an adjacent receiving water body. Flooding may occur when the drainage is incapable of storing and distributing the storm water from the land. A degraded aquatic ecosystem is usually associated with the discharge of the storm water. Green wall is actually a mulching technique as it covers the impervious surface of the building with plants and soil or planting medium. The green wall is able to retain water to control the water runoff from the roofs.

Urban green area and plants around the buildings can be viewed as an acceptable alternative habitat for urban plants and native wildlife. The presence of wildlife may enrich the ecological quality and health of the environment as well as provide additional emotional, intellectual, social and physical benefits to humans[8]. Apart from that, plants also release oxygen to the atmosphere through its unique photosynthesis, which breaks down carbon dioxide and water to create sugar and oxygen. This achieves not only oxygen generation, but also carbon dioxide reduction.

Plants roots also play a role in filtering the impurities in the water before it enters a groundwater aquifer. Impurities, such as nitrogen and phosphorus, will bond together with some type of soil. Plants can reduce the amount of these impurities in the soil by taking up nitrogen and phosphorus to be used in the plant growth.[8]

Lastly, plants can be used as sound barrier as the can reduce the noise perceived by the receiver. In the case of green walls, plants in the green walls will absorb the frequencies of the sound. Thus, reducing the noise pollution in the urban area.[7]

2.2.2 Economics benefits

All economics benefits are associated with the environmental benefits of the green walls. The ability of the vegetative surfaces to retain storm water and water runoff from the roofs can help in reducing the extend of the storm water drainage infrastructure.
Plants introduced around buildings can improve construction integrity by lessening the weather effect. The use of green walls can reduce the climatic stress on building façades and prolong the service and practical life of buildings and also not to mention reduced cost on the painting materials.[8]

Other than that, energy saving is another significant economic contribution brought by greenery in the cities. Studies have been done where the energy used for cooling in a building can be vastly reduced.Greenery can also add value to the property

2.2.3 Aesthetic Benefits

Landscaping is often used to improve the aesthetic value of the urban area. Vegetation can provide visual contrast and relief from the highly built-up city environment [6]. Plants also give the city dwellers a sense of closeness to the Mother Nature in the hard concrete jungle in the city.

Apart from that, natural landscape provides elements of natural scale and visual beauty as well as seasonal indicator to buildings and streets. In addition, the 'softness' of the greenery, compared to the hard surface of the concrete can also provide visual relief to plain walls. Ugly buildings can be hidden by the green walls and vegetations.

2.2.4 Social Benefits

Plants can fulfill various functions. According to Givoni (1991), plants provide places for playing, sports and recreation, meeting establishing social contacts, isolation and escape from urban life, aesthetic enjoyment, viewing buildings from a distance and so on. It has been proved that visual and physical contacts with plants can result in direct health benefits. Plants can generate restorative effects leading to decreased stress; improve patient recovery rate and higher resistance to illness.

3. Use of Green as Mitigation Measures for UHI

In order to better understand our climate, it would be incomplete without some notification and acknowledgement on the character and abundance of the plants as noted by Koenigsberger et al. (1973). Plants or greenery without a doubt, do play a part in improving our climate, regardless meso or microclimate. Plants provide shade from the sun and wind, decrease the air temperature, increase humidity, and reduce the surface temperature in the built environment and so on. However, the ability to change the climate is much decided by the density and the plant species. For example, an open lawn or meadow can do little to the climate as compare to a dense forest.

In general, plants can adjust climate through their unique shading, wind shielding, evapo-transpiration and photosynthesis processes. Most of the solar radiation were intercepted and seized by the dense foliages of the plants, except for a very small portion transformed into chemical energy through photosynthesis. The absorbed solar radiation are then modified to latent heat which converts water from liquid to gas, resulting in low leaf temperature, lower surrounding air temperature and higher humidity through the process of evapo-transpiration. In other words, the UHI can be alleviated through these mechanisms.[10]

4. Case Studies

The practice of incorporating plants into buildings became popular in the recent days, which is a different type of its own, The main focus of this concept is to make buildings biologically lively, to incorporate nature into the pile of spaces. This concept also consider local climate for its lighting and ventilation according with the use plants for cooling and refreshing the indoor environment and help decrease the heat gain from the outdoor, thus reduce the use of mechanical HVAC systems and resulting less use of energy. The following cases are considered here to study the recent typology of practices according with their views and concepts including indoor and outdoor planting.

4.1 Chilean Consortia Building, Santiago, Chile : Case Study of Outdoor Planting

Architect: Henry Browne - Borja Huidobro
Location: Las Condes. Santiago, Chile Santiago, Chile
Owner: National Trust Insurance - Life
Built Area: 26,720 m2
Surface: 3781 m2

Architects Henry Browne and Borja Huidobro have built the National Insurance building in Las Condes, Santiago, Chile. The building has various eco-friendly features that made it a sustainable one. One of the features is its interior and exterior thermo panels vegetation that absorbs the heat of the sun. Another great green feature it has is its front wall that turns into a vegetable garden of around 3000 square meters vertical, wherein the plants changes into different looks over the years depending on the season as shown in figure 7.[11]
The facades were developed with particular care [11]. The western orientation of the building is protected by the double facade construction that allows vegetation to grow on a system separate from the building. The vegetated facade makes up about 3,000 square meters. From the interior, it creates a lush barrier, shading its inhabitants from the beating sun and inside creating an atmosphere more like living inside in a secret garden as shown in figure 8. When the plants are not a luscious green, they turn colors of bright reds and yellows in the fall. While MFO Park using mostly cable system for the plants to grow on, there is a second track halfway up the structure that is like a large planter that runs the length and provides a second level of vegetation. The track also has an area for maintenance workers to walk and take care of the plants and lighting as shown in figure 9 [12].

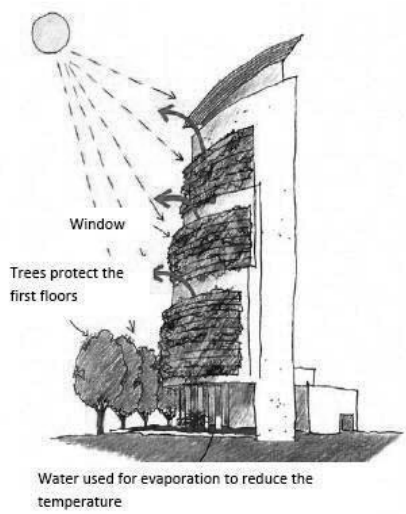

Figure 8. Concept drawing for the green façade. [11]

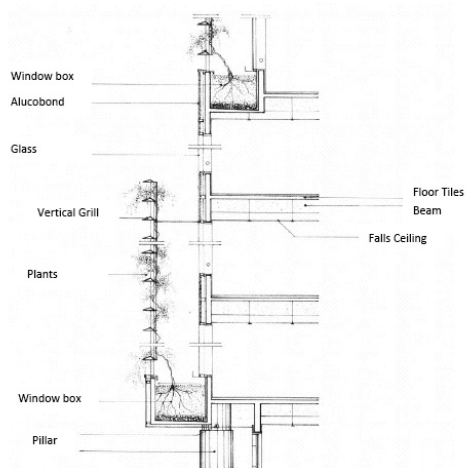

Figure 9. Detail Vertical Section. [11]

4.2 Tokyo Nara Tower, Tokyo : Case Study of Outdoor Planting

This 126 stories skyscraper will sited in cold climatic zone and deciduous forest type vegetation zone. This is a proposal for an ecologically responsive hyper tower. The tower is an extension of the park in sky idea. The design can be summarized as the architecture of the 'hollow rotating vertical spiral' using a system of shifting vertical landscaping terraces [13].

The verdant foliage protects the building by way of shading in the summer. By photosynthesis it creates a healthier microclimate at the façade. The fringing of the floors and the atrial spaces further reduces the impact of high wind speeds on the built structure. The ratio of the mass of planting relative to the built structure is favorably comparable, thereby ensuring that the biosystem components are balanced and acting symbiotically with the structure's mechanical and electrical systems as an artificial ecosystem as shown in figure 10.

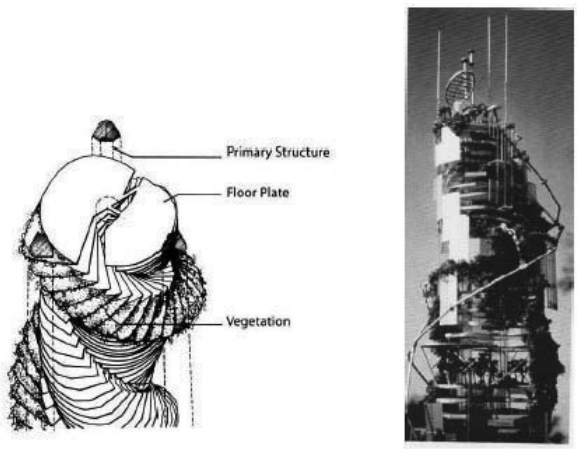

Figure 10. Tokyo Nara Tower, Tokyo. Plant integration with the spiral structure of the tower. [13].

The greenery in the built form, act as its lungs, like a breathing life into the floors, above and below, via the internal atrial voids [13]. The green lungs also refreshing the environment, improving the air quality and provide:

1. Vegetation on façade for sun-shading and microclimatic control.
2. Decorative landscaping for interior aesthetics.
3. Vegetation pockets located at public areas as natural air fresheners.

4.3 The Genzyme Center: Case Study of Indoor Planting

The Genzyme Center is an example of a company doing the right things and this building was chosen as an AIA Top Ten Green Project for 2004. The goal of the design was to develop a building from the inside out, from the individual working environment to the overall complex structure of the building [14]. There are eighteen gardens contributed to the green building concept. The building act as a living organism that would provide a connection to the outside through a visual connection with the outside, to look outside at the green and to bring that green into the building through the gardens and it was a high level of commitment to include the interior plants because it was the right thing to do for a green building as shown in figure 11.

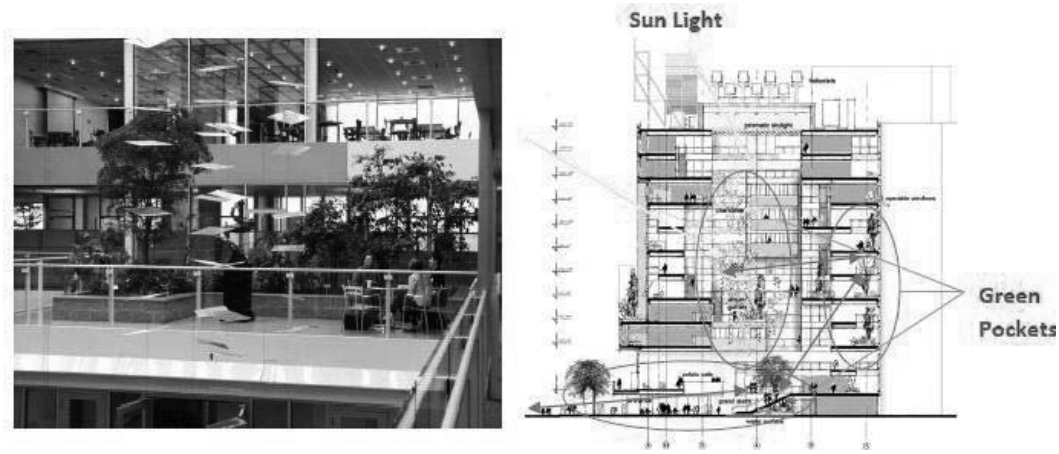

Figure 11. Indoor Planting in Genzyme Center. [14].

Interior planting in this building has mostly been met with a positive response. The air quality in the buildings is excellent, the shading and air-conditioning functions and also the aesthetic effect indoors are viewed positively. In administrative buildings, the number of staff off sick has decreased – the individuality of the workplace plays a role here.

Disucssion

'Sustainability' and 'green buildings' are buzzwords among building operators and developers. The recent launch of the new United Kingdom Green Building Council (UKGBC) is likely to increase the awareness. The Green Building movement is becoming ever more important as architects and developers strive to find ways of constructing and managing buildings in a sustainable and environmentally-friendly fashion.

The paper presented many ways to incorporate plants into buildings, as in roof, vertical walls, biofilters and in indoor potting plants. All these provisions have their own typology, technology of installation and maintenance as well as some drawbacks which need more extensive research to overcome.

There are options for the green wall design. It could be the climbing plants or the modular panels. For the skyscraper design both the options could be used together. For the lower levels the climbing plants, while rooted on the ground could be used in a designed manner, the hanging plants could be planted at the roof top which will cover the top most level's wall, while the modular panels could be used for the rest of middle floors. It could save time and money for the maintenance as those types of plants require little or no maintenance than the green panels.

Conclusion

Extending the plant or greenery onto the building façade has shown potential in improving air quality and reducing surface temperature in the built environment. Plants certainly helps to promote thermal comfort as they cools down the building façade and cools down the surrounding by transpiration. This can be perceived from the study as the outdoor environment remained at the thermal comfort range,where Plants give balance between temperature and relative humidity thus helps modify the outdoor thermal comfort. Therefore, the capability of the green walls in improving ambient air and temperature even though they do not act as a shading device has been identified.

Even though the basic mechanism for CO2 consumption is through photosynthesis, it is important to consider that relying on the green wall alone will not formulate a better environmental quality. Nevertheless it is a part of the method in contributing towards enhanced outdoor environment and maintaining the ecological systems in the urban area.

Recommendations

Ground coverage, green walls, sky courts, indoor plants and roof top gardens works together to make buildings 'Green'. The vertical landscaping is one variation on the creation of roof top gardening; another variation is the green wall, which encapsulates the principle of a single element with multiple functions [15]. The breathing wall with vegetated façade according with the sky courts tends to focus to develop the building as an ecologically complex and stable plant, microbial and human community, that helps to improve the air quality in an interface between natural processes and the built structure's environmental system. The whole system works for the social, ecological and environmental benefits. If this system multiplies and implemented to all the skyscrapers in an urban area the beneficiary will be all the species including the humans. The results will be the noticeable decrease in urban heat island, rapid reduction of energy consumption and refreshing air for a healthy environment.

Factors for Successful Green Facades

Design, installation and maintenance considerations for green facades and living walls will vary by system type selected and the conditions of the built and natural environment.

Green facade projects require that the designers, installers, manufacturers and maintenance staff take the following into careful consideration:

· Attachment to building envelope – how the system will be secured to the building or freestanding structure.
· Calculation of structural loads for larger systems, resulting from loads such as snow, plants, and wind.
· Plant selection for wind and light exposure, hardiness zones, and amenity context.

· Realistic expectations related to plant aesthetics and growth – some systems require 3 to 5 years to become fully established.
· Plant maintenance and/or long term maintenance plan to secure the health of these living systems, including proper soil and irrigation considerations.
· Check with manufacturers who may have registered or specially trained installers that will be able to complete the project successfully.
· Appropriate plant selection for the geographic region, correct plant spacing for desired coverage, and release from the temporary support structure used by the nursery.[16]

Educational Benefit of green roof and green wall: A socially viable issue
Green Roofs and Walls are the perfect tools to teach about the environment. The next generation needs to learn about the environmental concerns of today and how we addressing them. Problems like the Heat Island Effect, Global Warming, CO2 reduction in cities are all addressed by Green Roofs and Walls. Just a few of the topics that Green Roofs and Walls may b used for in education are:
• Ecological Observation
• Growing Plants and Vegetables
• Identifying the Protection of Buildings
Thus the educational opportunities are endless.

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