

# **1** Public Space & Pedestrian Realm

1.1 The Pedestrian Experience .....	2
1.2 The Street as A Social Place .....	13
1.3 The Green Network .....	25

# 1.1 The Pedestrian Experience

## A. Connectivity – The Public Space Network

### Description

A good public space network connects the different functions and public spaces of the city and invites people to walk, cycle and use public transit.

All public transit riders and motorists begin their journey as pedestrians and therefore the transit and automobile network can only be as good as the pedestrian network that brings them to other modes of transit.

### Design Considerations

#### 1. Connectivity - the public space network

A good public space network connects all the public spaces and city destinations with pedestrian friendly routes to create attractive and varied sequences of spaces in the city. An attractive pedestrian network offers good climatic conditions and interesting things to look at inviting people to walk.

An attractive network for pedestrians and cyclists is fine grained, with short distances and offers several choices of direct attractive routes between different functions. A fine grained network provides a balance between different modes of traffic but focus on pedestrians and cyclists since they are the ones keeping the city lively. A local network needs to be well-integrated with city-wide and

regional infrastructure. Transportation nodes are important destinations and should be well-integrated in the network to make it easy to change between transport modes and travel longer distances.

#### 2. Variation in use and character

A good public space network connects streets and spaces of different importance, use, size and character and create a city with a great variation offering different types of experiences and reasons to come. By introducing a hierarchy of streets and spaces in terms of importance, use and identity; city, neighbourhood, and local spaces a varied and legible city district.



All major destinations within short distances should be connected by high quality walking routes. *Lyon, France*

City life and pedestrian movement need to be concentrated in a few lively, attractive and safe main streets and spaces following the principle ‘to concentrate’ as opposed to ‘spread out’, to ensure an active public realm.

#### 3. Neighbourhoods and Identity

Existing activities and characters should be used as a starting point and the individual character of each street and space should be strengthened to create a varied public realm for everyday life as well as temporary events.



Public transport integrated at key nodes in the public space network. *Copenhagen, Denmark*

## Potential Market Street Application

To ensure the success and catalytic effect of the Better Market Street Project, the design must address how Market Street fits in the public space network and the wider hierarchy of streets and spaces. The examples shown here provide inspiration into how the wider context of Market Street can be conceived with a particular focus on:

- The relation between Market Street and its side streets in terms of role and use to inform the design of particular side streets and the intersections across Market Street.
- How the proximity of public transport nodes both located along Market Street and nearby (i.e. Transbay) can be better leveraged as a catalyst for public life, commercial viability, and perceived safety (passive surveillance)
- The relation between Market Street and its adjacent neighbourhoods. To identify how their distinct character and identity can manifest itself in design of Market Street

## Benefits

By enhancing the wider public space network, a highly accessible city with different types of experiences can be created.

Benefits for Market Street (the area and San Francisco) can include:

- More connected and accessible street and city destinations
- More attractive and walkable public realm
- More accessible public transport
- Improved legibility
- Synergy-effects between destinations
- A more spread out public life

## Other Information

Not applicable

## References

Gehl Graphic Library



Character and design of streets and spaces reflecting neighbourhood atmospheres. *Chinatown, New York, U.S.*



Federation Square is a major destinations for global, regional and citywide visitors. *Melbourne, Australia.*



More intimate local spaces for everyday life should be part of the public space network. *Copenhagen, Denmark*

## B. Pedestrian Accessibility

### Description

In order to be a world class street for people that invites more people to walk and spend time at Market Street, the designs need to ensure high pedestrian priority, accessibility and protection.

When traffic moves more slowly there tends to be more urban activity and more opportunities to meet in the public realm. This means that people that walk or cycle contribute more to the liveliness of an urban area. By making walking the most attractive mode of transport, by giving high priority to pedestrians, more lively and social environments can be created.

A good balance between the road users can be achieved by inviting people to walk, cycle or take public transport instead of the car.

### Design Considerations

#### 1. Generous sidewalks

To encourage walking it should be easy and attractive. A comfortable pedestrian landscape has wide sidewalks of high quality materials.

The effective width need to provide enough space for people at peak hours but shouldn't be so wide that they are perceived as uninhabited at a normal day. If the number of people walking on a sidewalk exceeds 13 4 people/minute/foot unobstructed sidewalk (people/minute/meter unobstructed sidewalk) crowding is experienced.

Sidewalks should follow pedestrian desire lines and provide direct routes and direct access to buildings, open spaces and destinations.

Sidewalks should be designed so that street furniture, trees, bicycle parking, signage, public transit stops, outdoor servings etc. isn't cluttering or blocking the designated area for walking. To ensure effective width a special "furniture zone" can be defined.

#### Unobstructed and generous sidewalks



Unobstructed sidewalks and sufficient space along pedestrian desire lines. *Lyngby, Denmark*

#### 2. Few sidewalk interruptions

Sidewalks are typically interrupted where vehicular traffic need to cross the pedestrian desire lines, at side street intersections mainly but often also by entrances to parking structures.

Sidewalk interruptions mean that the pedestrian need to stop, become aware of other modes of transport, force the slight change in level that the curb constitute and possibly wait for other modes of transport to pass. All this making walking less comfortable and efficient.



Zones for seating, trees and other furniture that provide enough space for pedestrians to stroll along the facades. *Melbourne, Australia*

## Side street intersection treatments enhancing the pedestrian experience



By taking sidewalks across side streets the pedestrian landscape becomes more comfortable with fewer interruptions. *Malmö, Sweden*



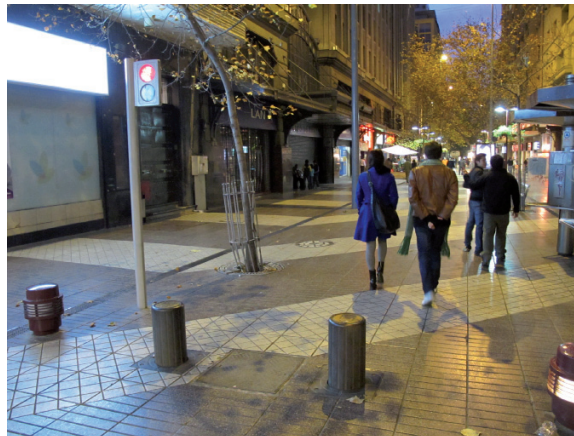
Partly depressed sidewalk for side ensures good accessibility for both pedestrians and vehicular traffic. *Paris, France*



Narrowing the street and a change of materials make it easier for pedestrians to cross the side streets and drivers are made aware of pedestrians. *London U.K.*



Change of material at intersection. *Mexico City, Mexico*



By closing off selected side streets to vehicular traffic, accessibility to the main street can be improved for various modes of traffic. Above: hydraulic bollards limit access to side streets at certain times of day. *Santiago, Chile*



Shared space can be used where pedestrian volumes are high and to enhance spatial qualities in certain locations. *Brighton, U.K.*

By keeping the sidewalk interruptions to a minimum, the pedestrian comfort of walking along a street can be improved. Such improvements can occur even at locations where other modes of transport need to be prioritized and/ or where the pedestrian needs to become especially aware of other modes of transport.

Different types of design interventions can differentiate a clear hierarchy between Market Street and the various types of side streets it crosses. This hierarchy should be informed by principles for good mobility for all.

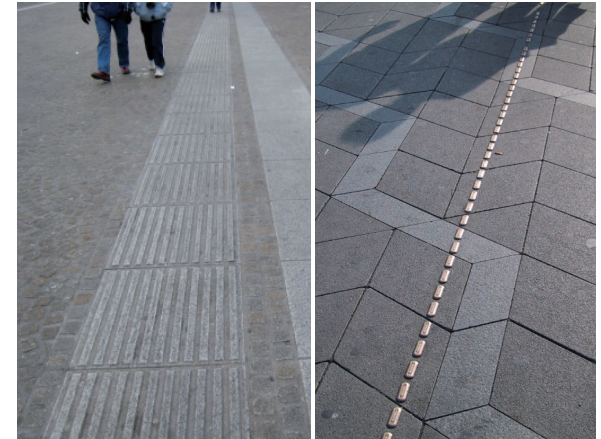
### 3. Access for all

Ensuring access for all is more than simply meeting ADA demands. Access for all is also about ensuring proximity to amenities, comfort and a high quality experience for all pedestrians. This means the pedestrian network should foster the most direct access to all local destinations, such as schools, work, and transit stations. The network should also offer a variety of pleasant and interesting routes. Streetscapes should be thoughtfully and artistically designed to draw more people to walk for both utility and pleasure.

### Access for all



Smooth transitions ensure access for all and contribute to a comfortable walking experience. *Copenhagen, Denmark*



Tactile paving indicating where to go and where to find a light rail stop for blind and near-sighted. *Amsterdam, Holland/ Copenhagen, Denmark*



Smooth paving providing access for users on wheels. *New York, U.S./Copenhagen, Denmark*



No differences in levels providing easy access to ground floor uses. *Ystad, Sweden*

## **Potential Market Street Application**

### **1. Sidewalks**

In general the quantity of space allocated to pedestrians is generous, yet the quality of that space is lacking. Under-used wide sidewalks feel deserted and unsafe. Zoning of street furniture is a way of expanding or contracting sidewalk space and provides a flexible solution for sidewalks that are too wide for the number of pedestrian users.

### **2. Side street intersections**

At more than 40% of the side street intersections on the northern side of Market Street, pedestrian desire lines are interrupted. At two locations people are forced to cross in two stages and wait in a traffic island.

### **3. Access for all**

Market Street should be designed as an universally accessible street. Existing issues like heavily textured paving, poor differentiation of paving between zones, lack of seating, and other characteristics will be reconsidered to meet universal accessibility standards.

## **Benefits**

The overall benefit of granting pedestrians the highest priority is that walking is encouraged and more lively, safe and social environments can be created.

At side street intersections, pedestrian friendly treatments provide:

- A more comfortable pedestrian landscape.
- Improved wayfinding.
- Higher awareness of pedestrians and reduced conflicts between different modes of traffic at intersections.
- Creation of new, larger and continuous public spaces by introducing shared space or side street closures at important nodes.

## **Other Information**

Not applicable

## **References**

Gehl Graphic Library

## C. Perceived Safety

### Description

Security is an important factor of public life. People will choose to visit the city if they feel safe during the day, as well as at night. 'Perceived security' and 'real security' are not identical phenomena and making a street that is perceived as safe is about creating a friendly environment that people find inviting.

The presence of residents and activities in the city add a sense of urbanity during both day and night. This urbanity helps people to feel safe.

Feeling insecure induces a stressful state of heightened awareness which most people would rather avoid.

To make a place more safe and inviting for everybody, day and night and all year around, it is necessary to work with a range of strategies at multiple scales, including: a good mix of functions in buildings, a wide range of activities in public spaces, safe walking routes, and inviting ground floor frontages with playful and intriguing elements.

### Design Considerations

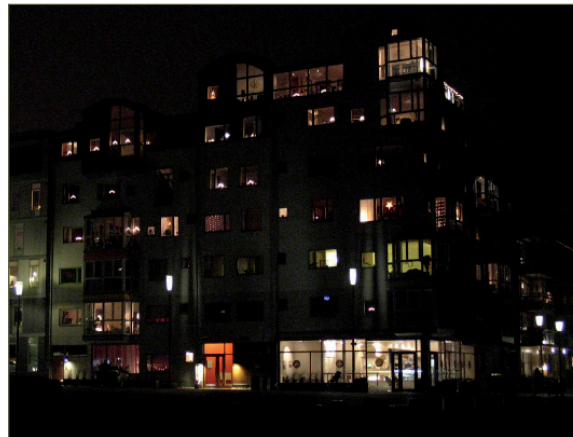
#### 1. Mixed-use

Diversity creates areas that are stimulating and vibrant, with a multitude of people and activities occurring at different times of the day, week and year. To create a lively city the public realm should be inclusive for all and create invitations for a wide range of user groups.

Diverse neighbourhoods provide their own natural surveillance because of higher number of inhabitants and visitors. Dwellings have the positive effect in generating life during the times



A good mix of functions in buildings and programming of open spaces contribute so the safety of the street because of the high number of people coming and going at different times. *Copenhagen, Denmark*



Mix of functions and transparency contribute so the perceived safety of the street by passive surveillance at different times. *Malmö, Sweden*



Lights in windows and visual contact between street and upper levels of buildings increases the feeling of safety. *Copenhagen, Denmark*



when other functions, such as commercial and offices, are closed. Lights on in windows in the evenings – indicators of ‘eyes on the street’ – give people the feeling that help is close by if trouble should arise.

Areas with one primary use, such as office buildings, tend to be areas that are only lively in the morning, at lunch time and again during the evening rush. Outside these hours, the areas appear deserted and can act as barriers within the city. The clustering of similar functions is detrimental for the city life and the perceived safety of the city.

## 2. Evening activities

The number and location of evening activities are important factors contributing to the vitality, as well as the perception of safety at night in the city. If there are few activities, areas of the city can be perceived as deserted and people will avoid them in the evenings.

## 3. Public transport nodes

Public transportation nodes are important destinations during the day, but also at night. Routes to and from the nodes, as well as waiting areas, need to be perceived and experienced as safe.

## Evening activities



Nighttime attractions with visual and physical contact to the street enhance the perception of safety. *Malmö, Sweden*



Encourage evening activities that activate public spaces e.g. bars and restaurants, cultural activities, events. *Melbourne, Australia*

## Public transport nodes



Transport nodes and waiting areas should be well lit and easy to overlook. *Melbourne, Australia*



Lights from underground stations enhance the public space above as well as making stations more visible. *Copenhagen, Denmark*

#### 4. Lighting

Sufficient lighting creates a general feeling of safety by improving the ability to find your way the ability to recognize the faces of passers-by. Furthermore, the scale and detailing of buildings and transparency and light from window displays is important at night. Poor visual quality and lack of orientation possibilities can create a feeling of insecurity.

Ensure that pedestrian routes and main public spaces are well lit. Basic functional lighting standards for pedestrians ensures safe and comfortable passage through the city. Principles for transparent and lit street frontages and lighting of entrances to buildings should be incorporated into standards. Artistic lighting could also contribute to making the city centre an exciting and intriguing night time destination. Artistic lighting can be used to stage individual spaces, buildings and areas.

Special lighting features can help create district identity. While not necessarily functional for creating basic illumination, special lighting can significantly effect the perception of safety, activity, and place making.

#### Street scape lighting



Carefully orchestrated lighting as a result of a lighting strategy. *Rue de la République, Lyon*



The public realm, streets and spaces should be well lit. Lighting should be directed at pedestrians and of human scale. *Brighton, U.K.*

#### Public space nodes



Place specific more artistic lighting when creating unique character for main public spaces. *Federation Square*



Artistic lighting of building and water features is differentiated from streetscape lighting. *Place de Terreaux, Lyon, France*

## Buildings



Lights in windows are part of the streetscape lighting and make the walking experience more interesting after business hours. *Copenhagen, Denmark*



Ground floors should be interesting to look at even at night. Use transparent and lit shop windows and avoid window shutters. *Perth, Australia*

## Potential Market Street Application

### 1. Mixed-use

Encourage a mix of uses that will provide a variety of invitations for people to spend time along Market Street. In places like the Financial District, consider interventions that are independent of ground floor function. In Mid-Market, explore how new uses could be integrated into a wider redevelopment strategy.

### 2. Evening activities

Consider programming for small and large scale public spaces along Market Street. Both temporary and permanent programming can be a catalyst for cultural, retail and leisure activities.

### 3. Public Transport nodes

Sections of the street that are in close proximity to transit nodes can be better utilized to allow people waiting for transit to occupy the street more actively

### 4. Lighting

A standard lighting scheme for the entire street could be augmented by district specific lighting interventions that reflect a unique character while maintaining the overall identity of the street.

## Benefits

Integrating residential, work, retail, and entertainment activities into one area makes for

better cities and better places. When everyday destinations are mixed together, as opposed to concentrated in separate spaces, many trips become short and walkable.

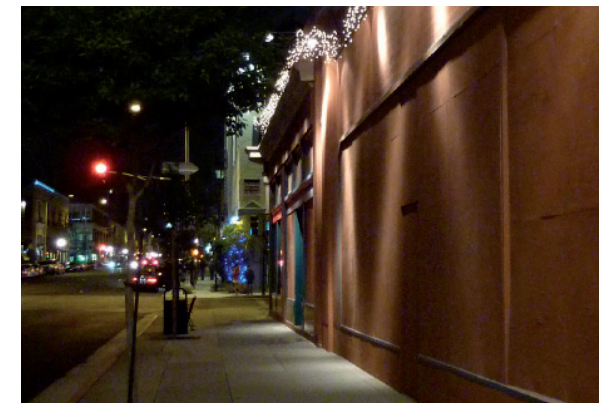
Time spent commuting or running errands can be reduced, as it becomes easier to combine trips. Liveliness attracts life, people attract people, local business thrive and diversify, and safety improves.

## Other Information

Not applicable

## References

Gehl Graphic Library



Lighting of an inactive facade improves the feeling of safety. *Perth, Australia*



Brighton, U.K.

# 1.2 The Street as A Social Space

## A. Edges that Enliven the Public Realm

### Description

Interaction between the built edge and the public realm create synergy between indoor/outdoor activities and stimulate public life.

The physical constraints of the human body, e.g. our height, walking speed, sight angle, etc. dictate the way we receive information. The level of activity and design of the ground floors largely determine how we perceive the built environment. What happens above is only vaguely experienced.

Studies have shown that the amount of activities in front of attractive and detailed ground floors are seven times that in front of closed and boring facades, meaning that good ground floor contribute to the experience of an interesting and lively town.

### Design Considerations

#### 1. Active ground floors

The most active functions should be located at the ground floor to enliven the public realm.

Great care should be taken to create transparent ground floors where activities taking place inside and outside can strengthen each other. Ground floor uses spilling out into the street, e.g. outdoor servings and product displays, invite people to stop and encourage lingering activities.

### Attractive built edges



Active and attractive ground floors integrate many units, many doors, and a high level of transparency. *Melbourne, Australia*



Ground floor activity spilling out into the public realm. *Copenhagen, Denmark*



Ground floor activity spilling out into the public realm. *Copenhagen, Denmark*



Niches offering protected places to stay and sit along the facades. *Brussels, Belgium*

Transparency, varied ground floors and fine detailing contribute to attractive and interesting environments. Small ground floor units and short distances between entrances, create an interesting visual environment and provide many invitations to come and go during the day and night.

Focus on creating active ground floors at the main streets and spaces so that intensity in use can be created.

## 2. Kiosks, pavilions and mobile units

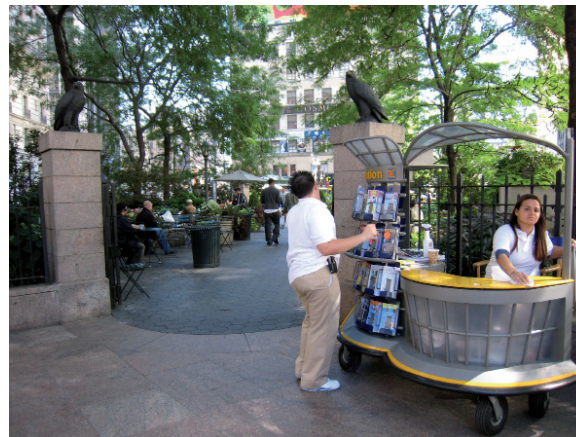
Kiosks, pavilions and mobile units enliven the public realm with new uses and can work as invitations for people to come or stay longer in a place.

Kiosks and mobile units are small in scale and can be flexibly placed to create attractive edges. Both permanent and temporary installations can also be used to improve climate conditions or to define the spacial character of a place.

## Kiosks and mobile units



Flower stand open at night - adding more eyes on the street in the evening. *Melbourne, Australia*



Tourist information kiosk. *Greenly Square, New York, U.S.*



Temporary units creating edge at human scale. *Copenhagen, Denmark*



Cheap and temporary units activating the public realm. *Malmö, Sweden*

## Potential Market Street Application

The entire 2-mile stretch of Market Street cannot be equally lively but the acquired understanding of how the built edge effects public space and the character of the street should be applied throughout.

The grain of Market Street between 5th and 8th is especially ripe for active ground floor frontages. Kiosks and mobile units can enliven the street where the building footprints are larger and monofunctional e.g. in the Financial district and between 8th and Van Ness Avenue. Built edges at plazas and other public space nodes will be given particular consideration.

## Benefits

The liveliest cities are those who stack lower-floor retail with residential and office functions above, in the most economical, convenient and vibrant combination. Combined with dynamic public spaces and plazas, mixing it up creates vibrancy in and above the streets.

Active and attractive built edges make people move more slowly and more people to stop. This enhances the notion of a lively environment by creating:

- More invitations to come, leave and spend time in the public realm
- Interesting visual environment and sensory experiences.

Built edges also provide spatial definition and can provide particularly attractive places for lingering activities when the climatic conditions are favorable.

## Other Information

Not applicable

## References

Gehl Graphic Library

## B. Seating Opportunities

### Description

Urban life is more than walking. The quantity of staying activities has the largest impact on the activity level in a public space. The activity level will rise remarkably when pedestrians or people indoors are tempted to spend time in comfortable outdoor public spaces.

Therefore, plenty of invitations for staying activities should be provided, such as a mix of public and private seating: benches, commercial seats, moveable chairs, sculptural seating and secondary seating on steps.

### Design Considerations

#### 1. Public seating

When inviting people to walk and enjoy the public realm it is important that different opportunities for pausing and resting are provided. Opportunities to pause should be provided along all main routes and in open spaces. Opportunities to rest should be provided every 330-feet (100 meters).

Designated seating zones should be carefully placed and oriented to ensure optimal opportunities for resting, lingering and people watching. This seating should be of high comfort, with back and arm rests. In addition, ensure that proper seating is located along main routes and by key destination for users with special needs.

#### Public seating



Opportunities to rest should be provided every 100m/330'. Comfortable benches with back and arm rests should be provided. *Bilbao, Spain*



Zones for seating, trees and other furniture that provide enough space for pedestrians to stroll along the facades. *Perth, Australia*

#### Private outdoor seating



A good mix between public benches and private outdoor servings need to be ensured. *Copenhagen, Denmark*



Outdoor servings allowing uses of buildings to spill out and activate the street. *Perth, Australia*



## 2. Private outdoor seating

Allowing cafés and restaurants to extend their usable area is not only good for business but also for street life.

The culture of outdoor café life has developed rapidly in many countries around the world. This has significantly changed the usage patterns of city centres. Today, summer activities are much more recreational in nature. Drinking coffee is an uncomplicated way of combining several attractions: being outdoors, enjoying pleasant views, and the ever present amusement of watching people pass by.

Over the past 20 years, the outdoor serving culture of Copenhagen has been expanding greatly. It has changed from being a daytime activity, to a day and evening activity and also expanded from summer to all year. Blankets and heaters are supplied during the cold winter to help guests feel more comfortable.

## 3. Social seating arrangements

Not all city goers want to passively take part in observing public life, but seek places to actively socialize with people they know or meet. Therefore, a good mix of seating that is spaced and oriented to invite for talking and listening one on one or in small groups should also be incorporated.



Seating arrangements with tables. *Battery Park, New York, U.S.*

## Social seating arrangements



Seating arrangement enabling social interaction between people. *High Line, New York, U.S.*



Moveable chairs providing multiple opportunities of use. *Paris, France*

#### 4. Secondary seating

Secondary seating opportunities play an important role in creating invitations for staying. Secondary, informal seating can be steps, built edges with niches, or artistic features that invite for people to use them when needed.

#### 5. Placement

Apart from the number of seating opportunities, the placement of seating opportunities need to be carefully considered. Factors such as views, climatic conditions, comfort, location and orientation to street activities, are important in order to provide a good seating ambience.

Seating should be placed so that key pedestrian desire lines are kept free.

#### Potential Market Street Application

There are today few opportunities to sit and rest provided along Market Street and in adjacent open spaces. Therefore an opportunity exists to consider multifunctional street elements (i.e. planters, art) that can double as secondary seating options.

Private outdoor seating can be conceived to complement public seating to encourage a good mix of users and activities.

### Secondary seating



Edges, steps and street furniture can function as secondary seating. *Federation Square, Melbourne, Australia*



So can niches in facades. *Copenhagen, Denmark*

Seating of all types could be integrated in areas where the demand is especially high, in close proximity to transit nodes, especially bus stops and areas of interest like the Powell Street Cable Car.

### Benefits

Space for activities and spontaneity invites people to spend time, which in turn promotes safety, economic activity and diverse street life.

Providing invitations for lingering activities, along the entire stretch of Market Street and at public space nodes will be a key in enhancing the recreational and social role of the street.

### Other Information

Not applicable

### References

Gehl Graphic Library



Seating should allow for people both to socialize and spend time in solitude. Brighton, U.K.

## C. Other Invitations to Spend Time

### Description

In the leisure oriented society, the recreative city life needs to be strengthened and diversified. There are many more opportunities besides seating that strengthen the social and recreational city life. This section illustrates other ideas for how people can be invited to spend time in the city. They focus not only on places to shop and work but also places to have fun and enjoy a city with other fellow citizens. These ideas can help people to use the city in new and different ways.

A layer of extraordinary experiences can be added in streets and spaces. Experiences that surprise and enrich the daily lives of residents, attract new visitors and inspire leadership to seek, change and pursue community engagement. The experiences may be permanent or temporary. There are many ways to do this: the sky is the limit!

### Design Considerations

#### 1. Events and other temporary uses

Temporary interventions can be a way of inviting people to use the city, its streets and squares differently, at new times and by new user groups. Events and temporary uses can be of very different character, carefully planned or spontaneous. For the best results events should be coordinated with special activities that engage the local community and invite public involvement.

### Events and other temporary uses



Planned events provide opportunities to invite people at times where use is low, e.g. evenings, sundays, winter etc. *Copenhagen, Denmark*



Spontaneous cultural activities inviting people to stop for a while. *Copenhagen, Denmark*



Every Sunday the street of Ginza, one of the most prominent shopping streets in Tokyo, completely transform in to a public place. *Ginza, Tokyo, Japan*



Temporary spaces can invite for new uses and become temporary attractions. *Berlin, Germany*

## Playing



Elements for playing integrated in the urban environment invite several user groups. *Stuttgart, Germany*



Playful city elements create activities and dedicated spaces for both families and children. *Bryant Park, New York, U.S.*

## Physical activities



Activities for young people integrated in the city environment mix them with other user groups. *Lyon, France*



Physical activities integrated into the landscape. *Copenhagen, Denmark*

## 2. Play and physical activity

The public realm should provide opportunities for both passive and active recreation. Invitations for playing and physical activity will allow for new types of activities to take place and be visible in the public realm. This can be a way of inviting a wide range of users.

Seating opportunities should be provided by places for active recreation, since watching can be an interesting activity.



Even blank walls can invite people to stay for a while. *Malmö, Sweden*

### 3. Art and elements for sensory experiences

Art can be part of the public realm in many different ways. It can be visual (to look at) or interactive (inviting for physical activity and dialogue), permanent (as part of the built environment) or as freestanding objects. Together, art expressions enhance specific places and areas.

#### Potential Market Street Application

By introducing a range of interventions, the open spaces along Market Street can be strengthened. Art, events and similar initiatives can be used to highlight the specific use and character of each node and differentiate places along the street.

Consider how certain types of initiatives can improve the entire length of the Market Street and benefit from cooperation.

#### Art and sensory elements



Freestanding object enhancing the character of a space and create landmarks or meeting points. *Bilbao, Spain*



Temporary art installation offer opportunities for local engagement. *Malmö, Sweden*



A sculpture or a fountain can be a place for seating and vibrant activity. *Copenhagen, Denmark*



A fountain can also inspire interaction and play. *Copenhagen, Denmark*

## Benefits

Working creatively with art, events and other initiatives provide possibilities to:

- Strengthening the recreational use of Market Street.
- Invite a wider range of user groups.
- Activate the street and adjacent spaces when they are under-used.
- Engage neighbouring communities, organizations and businesses.
- Creating a dynamic and surprising city environment.

## Other Information

Not applicable

## References

Gehl Graphic Library

## Information and technology



Internet hot spot invite people to spend time in the public realm. *Berlin, Germany*



Outdoor library. *Bryant Park, New York, U.S.*



Exhibitions and information part of public realm. *Copenhagen, Denmark*



Exhibitions and information part of public realm. *Copenhagen, Denmark*



Trees on Las Ramblas create a visual connection and act as a street signifier. *Barcelona, Spain*



# 1.3 The Green Network

## A. The urban forest

### Description

The urban forest is a complex system of seen and unseen infrastructure. The trees and understory plantings are at the core of the experiential and ecological qualities of a healthy green environment.

Trees add to a city's beauty, quality of life, and cultural neighborhood identity. Trees increase property values, create shade, microclimates, as well as, scale and frame spaces. Ecologically they take on a different but equally critical role of decreasing flooding, global warming, stormwater runoff, filtering air and water, and creating habitat.

### Design Considerations

#### 1. Experiential

A good green network should create a stronger and more resilient vegetative infrastructure. A network of trees and vegetation should add to the experiential qualities of living in a city. Being in close proximity to the trees relieves stress, anxiety, increases quality of life, civic pride, and defines city neighborhoods.

#### 2. Ecological

A good ecological green network will successfully create a system which increases resiliency by decreasing stormwater runoff, filtering air and water pollutants, and creating habitat.

### Potential Market Street Application

The entire two mile stretch of market street should be successfully vegetated creating microclimates, defining spaces, beautifying and most importantly create a central green boulevard that connects San Francisco to its waterfront.

The trees on Market street face significant challenges in terms of wind, pollution, inadequate sunlight, soil depth and the threat of physical damage. To ensure success of a sustainable vegetative network, urban soils and stormwater need to be studied and integrated into a combined vision.

Trees roots on Market Street face giant obstacles. The intricate underground infrastructure limits tree pit sizes and above ground transit, car and foot traffic compacts adjacent soils. Ideally, tree pits need to be sized and combined for extended lateral root growth creating the best chances for survival, size and stability. A resilient mix of species that is suitable for San Francisco's climate, urban conditions, and bird life should be integrated into the plan for optimal sustainability.

Numerous areas of Market Street lack the well cared for trees that help attract business, clients and consumers as well as define districts. There are numerous trees that are poorly pruned and damaged that should be removed and replanted to enhance the ecological connectivity of the street. The tree system should be considered both on the

micro and macro scale. Since there are numerous microclimates on Market Street, each block should be examined and the best approach should be determined but the larger intent and vision of a green street should remain intact.

The system of trees through natural and environmental causes is consistently changing and adapting. A goal of successful succession should be in place to replace and revive Market Street as it's urban forests grows, matures and changes.

### Benefits

By adding trees and vegetation Market Street can benefit greatly and be the epitome of sustainability that defines the greater San Francisco Bay Area.

- Beautification and Quality of Life.
- Health and the Reduction of Stress.
- Defining Space and Creating Identity.
- Shade and Microclimate.
- Filtration of Air and Water.
- Decrease flooding and Global Warming.
- Create Habitat.
- Increase Tourism.
- Increase of Business, clients and consumers.
- Increase Property Values.

## References

(1) US Forest Service

<http://www.fs.fed.us/psw/programs/uesd/uep/>

(2) Friends of the Urban Forest - San Francisco:

<http://www.fuf.net/resources/links.html>

(3) "City of San Francisco, California Street Tree Resource Analysis", Scott E. Maco, Gregory McPherson, James R. Simpson, Paula J. Peper, Qingfu Xiao

(4) Center for Urban Forest Research; University of California, Davis, <http://cufr.ucdavis.edu>

(5) The University at Illinois at Champaign Urbana Human-Environment Research Laboratory, [www.herl.uiuc.edu](http://www.herl.uiuc.edu)

(6) Center for Urban Horticulture, College of Forest Resources, University of Washington, [www.cfr.washington.edu/research.envimd](http://www.cfr.washington.edu/research.envimd)

(7) Trees Matter, Trees for London and the National Urban Forestry Unit

(8) The Urban Forestry Manual, USDA Forest Service Southern Region, Southern Research Station, and the Southern Group of State Foresters

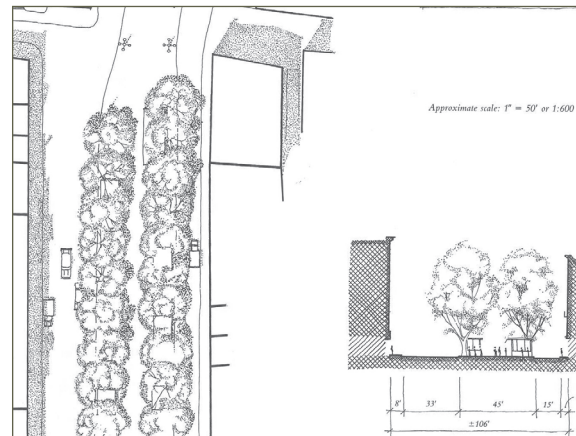
## Las Ramblas Street Trees



Trees create canopies, shade, and microclimates, offer beautification, civic pride and increased tourism on Las Ramblas. *Barcelona, Spain*



Trees can create structure, scale and define pedestrian space. *Barcelona, Spain*



At certain sections of Las Ramblas a widened median house small vendors and significant structural street trees. *Barcelona, Spain*



Trees on Las Ramblas create a green connection to Barcelona's waterfront. *Barcelona, Spain*

## Street Trees



Street trees thrive in tight infrastructural conditions between a drive, parking and a canal. *Amsterdam, Netherlands*



Trees on the urban Boulevard Saint-Michel, define the sidewalk edge. *Paris, France*



Trees and understory vegetation define and structure seating spaces in Bryant Park. *New York, NY*



Above grade transit is successfully combined with street tree allées on the Ringstrasse. *Vienna, Austria*



Trees lined streets with movable bollards expand the sidewalk when desired. *Quebec City, Canada*



Tree lined street with usable understory and suspended tree grates allow space for dining and walking. *Madrid, Spain*

## B. Urban Soils & Stormwater

### Description

To achieve a healthy urban forest many unseen factors need to be addressed. Urban ecosystems face conditions that are hostile and un conducive to root growth and overall plant health. Soil quality is linked to numerous indicators of a healthy environment. Soil character affects water quality, plant and animal life, the ability to filter potential pollutants, and recycle nutrients.

### Soil Compaction

Construction, transit, car and even foot traffic can seriously reduce soil porosity. The area in between soil particles has a varying degrees of water and air which is in a constant state of flux. When porosity is reduced or removed due to compaction the air and water is removed reducing the potential for healthy root development.

The bulk density or compaction rate of soil, is a way of measuring soil porosity. Soil compaction is most acute on its surface or point of compaction. Compaction rates reduce with depth and loads are spread and reduced laterally and not directly downward.<sup>1</sup> Compaction also varies with the weight, as well as, the surface area of the object. For example the Historic F line streetcar that runs down market is less likely to compact the soils than a standard truck or car.<sup>2</sup>

<sup>1</sup> *Up by the Roots: Healthy Soils in the Built Environment.* James Urban. p. 34  
<sup>2</sup> *IBID.* p.35

A basic function of soil is to deliver water to roots in a fast an effective manner. After a rainfall, water percolates from the pull of gravity to lower root structures ultimately being replaced by oxygen allowing for root respiration. This process is an essential and critical to plant health and if the bulk density of the soil is too high the water is never replaced by oxygen and the roots basically drowned.

The lack of water percolation is major problem in urban soils. Once soils have been severely compacted it is very difficult to have them return to optimal aerobic condition. Anaerobic soil conditions also create adverse environments for soil microorganisms which are critical foundation for healthy soils.

Another key component of soils is organic matter, or carbon. Organic matter is essential to the cohesion of soil particles. This, in turn, affects the quality of root penetration and overall plant health. Organic matter also plays a role in soil fertility and productivity. It aids in the soil's ability to hold nutrients, air and water for later uptake by plants. It also provides the food needed to keep beneficial organisms to live.

With the increase of soil's organic matter CO<sub>2</sub> levels can be reduced helping moderate climate change. High levels of organic matter filter and help alleviate toxin levels and keep them from

reaching groundwater. This natural cycle is hindered in an urban environment because organic matter is not replenished due to the removal of leaves and the reduced decomposition of roots and microorganisms from compacted soils.

### Structural Soils

Structural Soils are essential for the building of roads and infrastructure but can be detrimental to roots and plants in not engineered properly. When non-structural soils are compacted they can never be fully rehabilitated, hence the necessity for soils that can provide structure as well as allow for root growth. Structural soils and non-structural soils need to have a balance to either create or correct adverse conditions for tree growth and infrastructural bases.

Research at Cornell University suggests that urban street trees across most of the United States require two cubic feet of soil per foot of "crown projection".<sup>3</sup> Obtaining an adequate amount of soil that supports good tree growth can be a serious challenge from both a structural as well as cost standpoint.

Structural soils have been engineered to allow for a porous structure to alleviate compaction. Large sidewalk corridor pits offer a great potential to hold and protect adequate soil for the growth of

<sup>3</sup> *Trees in the Urban Landscape: Site Assessment, Design, and Installation.* Peter J. Trowbridge and Nina L. Bassuk. p. 64

multiple trees at once. A natural forest can serve as a model of this advantageous grouping. In the forest, a tree's roots share soil space with other trees and plants. This concept can be taken into account by recreating a soil space large enough to allow for multiple tree root systems and is therefore beneficial to the trees' growth.

The development of the "gap-graded" soil system allows a proctor density of 100, which is both good for pavement requirements and has the porosity for root growth. Course, angular gravel from 3/4 to 1 1/2 inches is used with no addition of fine-grained soil and retain the essential high level of porosity needed for tree growth.<sup>4</sup> This is compacted and the friction creates load-bearing requirements for pavement.

Structural soils are most helpful when they are utilized on sites with an absolute need for infrastructural stability like Market Street. When used as a base under pavement for pedestrian usage, a Cornell study found that with a proper mix, trees can actually grow well.<sup>5</sup> But all the compaction can lead to drainage problems. To combat underlying drainage problems caused by structural soils fully engineered planting beds with drainage systems can be being specified.

The pH level is another factor to consider when

<sup>4</sup> Trees in the Urban Landscape: Site Assessment, Design, and Installation.

Peter J. Trowbridge and Nina L. Bassuk. p. 65-66

<sup>5</sup> IBID p. 66

deciding on the type of soil. Due to the high concentration of rocks used in the structural soil the pH balance can become a problem. The pH level of concrete is a major culprit, creating rising levels during its breakdown. Peter J. Trowbridge and Nina Bassuk of Cornell University recommend using street trees that can manage in alkaline soils but also respond to well to drained soils, which is a reaction to the pH balance and the inability for course gravelly soil to retain water.<sup>6</sup>

### **Cantilevered Hardscape and Large Cell Soil Frames**

Alternative solutions to structural soil include the cantilevering and/or supporting of hardscape materials atop a structure that can handle the specific weight load requirements without compacting the planting soils. Cantilevered systems have been tested at Lincoln Center in New York City, and "Silva Cell"™ systems have been utilized in Mint Plaza in San Francisco.

### **Stormwater**

Urban runoff can be reduced by detaining water in planting areas and soil systems before releasing it to the storm drain system, thereby reducing the flow volumes. This is especially desirable in places that use a Combined Sewer Overflow

<sup>6</sup> Trees in the Urban Landscape: Site Assessment, Design, and Installation.

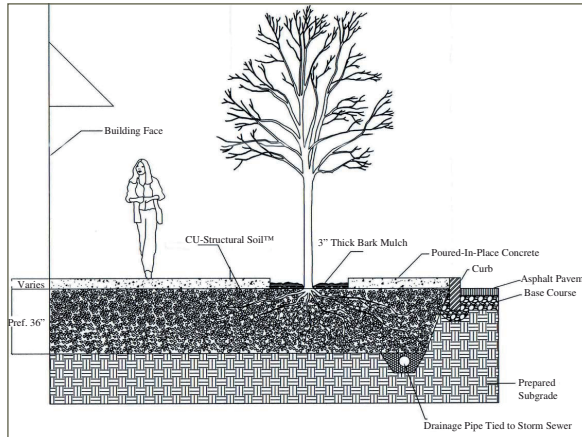
Peter J. Trowbridge and Nina L. Bassuk. p.70

(CSO) treatment system, where stormwater flows impact the capacity of treatment plants. Infiltration / detention basins can be installed below paving systems, such as the system implemented at Mint Plaza, and significantly reduce the quantity of stormwater runoff. Detention system are limited by their volume capacity and/or the permeability of the underlying soils.

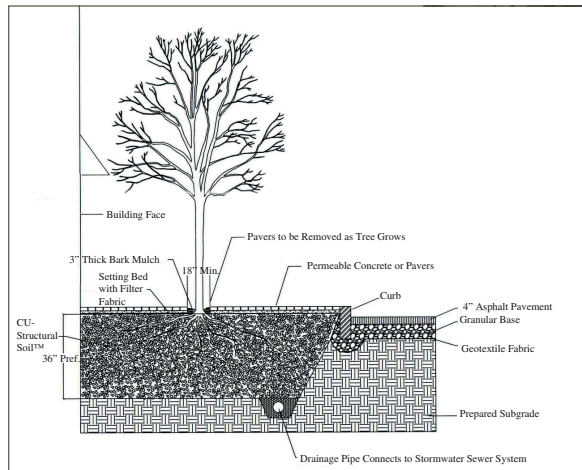
Biofiltration systems improve the quality of urban runoff by filtering the water thru planting and soil mediums before the water is discharged to the storm drain system. Unlike detention systems, filtration systems can be much smaller and are not as affected by the underlying soils, and are feasible as fully enclosed systems over on structure conditions. If site conditions are optimal, biofiltrations and detention systems can be combined.

This application on Market street will require the use of numerous methods possibly including a combination of structural and non-structural soils and cantilevered or soil frame hardscapes, and stormwater treatment designs.

## Structural Soil



Structural Soil with poured in place concrete.



Structural soil with permeable paving.

## Suspended Pavement



Lincoln Center Plaza suspended pavement structure during construction. *New York, NY*

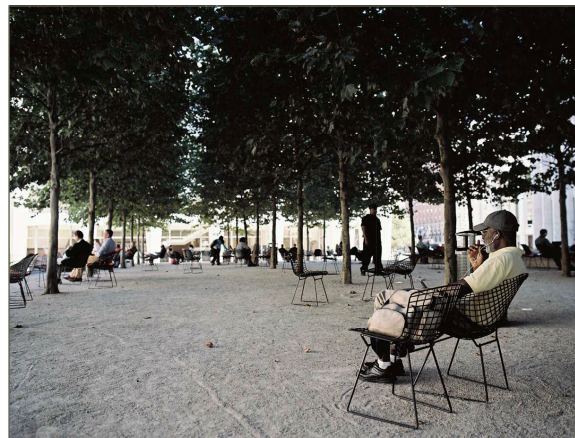
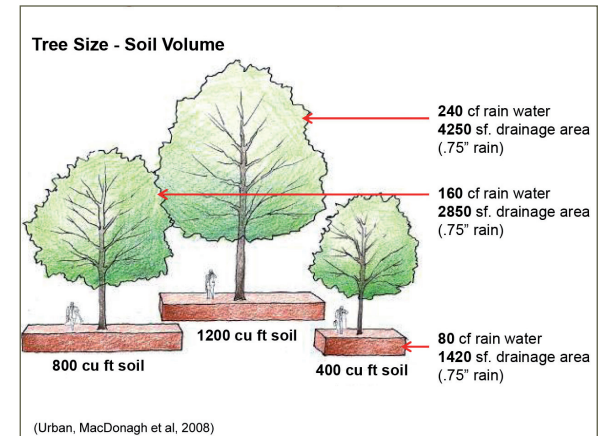


Image taken after construction at Lincoln Center Plaza with structural soil infrastructure installed shows trees thriving. *New York, NY*



Permeable paving suspended above structural soil allows for stormwater filtration and root development.



Tree size to soil volume with rain water and drainage areas.

## Design Considerations

### 1. Experiential

- Attractive stormwater rain gardens and decorative bioswales that create habitat potentials.
- Larger and stronger tree canopies from optimal soil conditions.

### 2. Ecological

- The increase of non-compacted, permeable and well draining soils will require larger, connected and continuous tree pits.
- Structural soil and suspended pavement for strength, planting, and drainage.
- Soil fertilization and aeration regime.
- Permeable paving.
- Capture and filter stormwater before draining to the bay.
- Reduce potential flooding.

## Potential Market Street Application

Market street can showcase the potentials of an urban forest's unseen soil infrastructure. Currently, the heavy needs of transportation both above and below grade create tight restrictions for sizable tree wells and street-side rain gardens for biofiltration. The lack of thriving green trees and vegetation on Market Street is an apparent aesthetic and ecological issue that is directly affected by the density and volume of the soil below grade. Compacted soils in turn directly affect stormwater permeability and filtration potentials. Structural Soils and cantilevered hardscape can be used as possible solutions to compacted soils.

## Benefits

- A resilient green infrastructure.
- Reduced stormwater runoff and a healthier San Francisco Bay.
- Soil aeration and drainage.
- Attractive greenery and seating opportunities from rain gardens and bioswales.
- Slow down runoff to the combined sewer system and attenuation of peak flows.

## References

- (1) Can Urban Soil Compaction Can Be Reversed, Article 37, *The Practice of Watershed Protection*, editors Thomas R. Schueler and Heather K. Holland, Center for Watershed Protection, Ellicott City, MD. (2000) 1(4): 666-669.
- (2) Center for Watershed Protection Article 36. Technical Note # 107 from *Watershed Protection Techniques* 3(2) 661-665. *The Compaction of Urban Soils*.
- (3) Deep Root. <http://www.deeproot.com/>
- (4) *Growing the Urban Forest*. James Urban. [http://www.toronto.ca/planning/pdf/james\\_urban.pdf](http://www.toronto.ca/planning/pdf/james_urban.pdf)
- (5) *Trees in the Urban Landscape: Site Assessment, Design, and Installation*. Peter J. Trowbridge and Nina L. Bassuk. John Wiley & Sons, Inc. Hoboken, New Jersey. 2004.
- (6) *Up by Roots: Healthy Soils and Trees in the Urban Environment*. James Urban. International Society of Arboriculture. 2008.
- (7) Protecting Urban Soil Quality. [http://soils.usda.gov/sqi/management/files/protect\\_urban\\_sq.pdf](http://soils.usda.gov/sqi/management/files/protect_urban_sq.pdf)

## How Much Soil to Grow a Big Tree

