CONCEPT OF URBAN STREET PLANT AREAS FORMATION

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Abstract. In the process of forming aesthetical, hygienic and safe environment of the street, an important role is played by street plant areas. The article presents the concept of the street plant areas, their main elements and functions. The article also analyses the existing state of the street plant areas: assessment of the planning of plant areas of the street; purpose of selection of the range of street plants; correctness of planting and care of the plants. Summary of the analysis results enabled the authors to define the principles of formation of plant areas on urban streets and individual elements of streets.

Key words: urban street, concept of street plant areas, key elements of street plant areas, results of existing state analysis, principles of formation street plant areas.

1. Introduction. Concept, key elements and functions of street plant areas

The street plays an important role in the formation of urban environment. The street sees intensive movement of vehicles and pedestrians, regulation of flows and information provision, free and organised socialization of people, short rest, review of street building architecture, visual information and advertising, etc. The extent of these functions depends on the street category (Figure 1). In this process of forming aesthetical, hygienic and safe environment of the street, an important role is played by street plants. The analysis of the main rules of and recommendations for street engineering [1,2] reveals that an overall conception of street plans does not exist, their main elements, functions, etc. are not highlighted; therefore, the authors tried to fill in this gap.

Fig 1. Priority scheme of different urban street categories

A plant area of the street is a whole of planned and planted (with trees, bushes, flowers and grass) areas of the street ensuring normal functioning of traffic, meeting pedestrian needs and forming aesthetic environment. Plant areas consist of individual green elements of the street: the zone between a sidewalk and buildings – the building green zone; the zone between the sidewalk and the carriageway – the sidewalk green zone; the central separating zone between opposite direction traffic lanes – central separating green zone; intersection zones and isles of different types and forms – intersection green zones and isles; the special green zone of underground engineering networks and the special zone for protection against air pollution – the protective green zone (Figure 2).

Fig 2. Street elements that form the street plant area: a – the building green zone; b – the sidewalk; c – the sidewalk green zone; d – the special green zone of underground engineering networks; e – the carriageway; f – the central separating zone; g – the protective green zone.

The green street elements should form an undivided unit of plant areas of the street as only then they will fully
2. Results of the analysis of the existing state of plant areas of the street

The analysis of the state of plant areas of the street was carried out in three directions: assessment of the planning of plant areas of the street; purpose of selection of the range of street plants; correctness of planting and care of the plants.

2.1. The main weaknesses in the planning of street plant areas

In Vilnius, with regard to the planning of the street plant areas, A-D category streets, their parts and elements were analysed. The following streets were covered: Geležinio Vilkos, O. Milašiaus, Švitrigailos, J. Basanavičiaus, Mindaugo, A. Vivulslio, Tuskulėnų, Raitininio, Krokuvos, other streets, Gedimino and Konstitucijos avenues, etc. The carried out analysis of the existing state of urban streets shows that the planning nature of street plant areas, dimensions of the elements of the planted areas sometimes are determined without taking account of the following: natural climatic conditions of a location; position and functions of the street in the planned urban spatial structure; the street category (changes in the carriage way and in other elements of the street); the existing and forecasted traffic intensity; the level of noise and air pollution; the size of pedestrian flows; the needs of disabled people; the position of the street with regard to cardinal points; the proportion with regard to neighbouring buildings and their characteristic features; the layout of street lights and traffic-lights; the impact of plants (trees, bushes) on safe traffic, clear visibility, comfortable maintenance of the street, protection of pedestrians from possible violence, creation of uniform style of the small architecture and formation of distinctive architectural style, etc. (Fig. 3, a, b).

Fig 3. Incorrect planting of trees in the street plant zone elements: a – trees in the building zone; b – streets in the sidewalk plant zone.

Specialists of Transport and Road research Institute, Skrodenis and Abukauskas, are right saying that “it is not the view of the settlement that should accord with the road; it is the road that should accord to the view of the settlement, as the residential area is first of all intended for people and only then for vehicles, so it should be attractive, aesthetic, and comfortable” [4].

2.2. Purpose of selection of the range of street plants

The analysis of the street plant areas of Vilnius and other towns of the country reveals that in mid 20th century the main plants of the streets, trees, usually played only an aesthetical role. The tree had to be high and with the nice leaf. Therefore, today in many old streets trees obstruct the street space, their branches reach windows and walls of buildings, prevent the day-light from getting into buildings, aggravate street ventilation, obscure street lights and traffic regulation installations. And softening of this impact by trimming the trees of an expensive measure which is also harmful to the old trees. Besides, seedlings of trees were from local forests and at present they do not suit to the changed conditions of today’s town: lack of humidity, pollution of the soil with salts and chemical substances, concentration of emissions in the air, dog urine, frequent excavation harming tree roots, etc. All this harms the existing trees; the trees are attacked by vermin and get sick or even die. This becomes the problem of the town. It should be noted that this problem is topical to almost all old towns of Europe [5].

Due to rapid growth of towns, increasing building density, rising level of automobilisation, thickening network of streets, and increasing pollution, the plants must play a multifunctional role instead of being just aesthetical objects. Because of their physiological properties (improvement of air composition and microclimate, reduction of air pollution, reduce noise, etc.) plants are intended to for healthy, comfortable, functionally-grounded and aesthetic environment of the street. Therefore, today it is necessary to grow plants (trees) that are resistant and easily adapting to the urbanised surroundings; besides, such plants should take little place in the street space. Thus, it is recommended to use local and introduced tree breeds and species that are specially selected to grow under urban conditions. For that special 12-15 year old plants should be used; when planted they should already have a branch system formed in a container from which they are removed just before being planted; the tree roots should be in special bundles containing soil lumps, and only in exceptional cases they could be planted bare-rooted. It is recommended that trees with narrow and small spherical, oval and similar leaf are used for the street green areas [6]. In Lithuania good plants for streets are offered by UAB Saltra (Trakai), UAB Kika flora (Zapyškis), etc.

2.3. Correctness of planting and care of the plants

The analysis of the existing state of the urban street plant areas reveals that to form fully-fledged plant areas it is important to properly prepare the place for planting and to take good care of trees, bushes, flower beds and lawns. According to the analysis results, the leaf of a standard mature tree should be 4x4 m. It follows then that the place for its roots should about 16 sq. m. Sometimes, trees with larger leaf could be planted on the street or on its individual elements; however, in such case the place
needed for roots should also be appropriately larger. For that reason it is necessary to make ready a pit for a plant in the place of its growth and then, when the plant is in the pit, it should be poured with high quality soil with good water and air permeability and with the ability to neutralise harmful substances, and the branches should be protected from becoming too thick, the plant should be regularly watered, fertilised and drained [7]. It should be noted that these issues are not being properly solved on urban streets. Therefore, the initiative Vienna Municipality (Austria) in 2007 to set up a group of scientists and planting specialists that has to establish the technology of planting and offer recommendations for the composition of the soil to be poured on the roots of the plant is welcomed [5]. At present, in Germany much attention is paid to selection of plants and their correct planting (Fig. 4).

![Fig 4. Principle scheme of the tree planting when forming street plant areas in Germany](image)

Another important issue related to street plant care is continuous trimming of trees and bushes. The analysis shows that often thinning or removal (to keep the trunk without branches 3.2-3.6 m from the ground) of leaf and cutting of the treetop (when it interferes with overhead communications) are not satisfactory. Solutions of these issues if better on reconstructed or newly build streets, for example Konstitucijos and Gedimino avenues in Vilnius (Figure 5).

![Fig 5. Correctly formed street plant areas in Gedimino avenue in Vilnius.](image)

3. The key requirements for urban street plant areas

The urban street plant area consists of separate green elements of the street: the building green zone; the sidewalk green zone; central separating green zone; intersection green zones and isles; the special green zone of underground engineering networks and the protective green zone. Solution of these green elements of streets in the process of street plant area formation should be complex so that a uniform view of a modern street is obtained. However these green elements of the street have to satisfy a range of aesthetic and functional requirements that should be taken into consideration when creating the street plant areas. A short description of the elements is given below.

3.1. The building green zone

The building green zone is built in the town between the line of buildings and the red line of the street. This zone contains entrances to the buildings, plants, etc. The width of this zone between buildings and the sidewalk may be very different and it actually depends on the category of the street and on urbanistic architectural solution of buildings.

Constructing buildings at the line of the sidewalk, where there is no possibility to make the building green zone, it is recommended that the existing buildings are decorated with vertical planting by growing voluble and climbing woody plants (lianas) at the buildings. For that 0.5x0.5 m holes have to be made in the sidewalk, and liana stems have to be protected by 0.5 m high metal fence. For vertical planting it is recommended to grow Engelman's ivy (parthenocissus quinquefolia var. engelmannii), Virginia creeper (parthenocissus quinguefolia var. muromur), Brown's honeysuckle (Lonicera x brownii), Italian honeysuckle (Lonicera caprifolium). Most of them need special supports to be able to adhere to the wall. At present, the countries of Western Europe use different type containers with flowers, small bushes, etc. planted in them; such containers are attached to the walls or put on the sidewalks (Figure 6, a, b).

![Fig 6. a, b – Containers with flowers, small bushes, etc. planted in containers attached to the walls or put on the sidewalks are used for town decoration.](image)

In the building green zone wider than 5 meters simple lawn is sown and different compositions of blooming small bushes are arranged on lawn [7].

In the building green zone wider than 10 meters a single tree (solitaire) or a small group of several trees
could be planted keeping the distance of at least 10 m from the external walls of the building or the structure to the tree trunk. Where trees with leaf wider than 4 m are planted, then the width of the building green zone have to be increased by 0.5 m per each increase of the branch system by 1 m. Planting trees close to the buildings it is necessary to consider insolation and light requirements.

Table 1. Minimal distances of trees and bushes from buildings and structures

<table>
<thead>
<tr>
<th>Buildings, structures and underground engineering networks</th>
<th>Distance to the centre-line, m from the tree trunk</th>
<th>from the bush</th>
</tr>
</thead>
<tbody>
<tr>
<td>In the building green zone that is at least 15 m wide trees are planted on lawn near the sidewalk so that the leaf covers the sidewalk.</td>
<td>0.7–1.0</td>
<td>0.5</td>
</tr>
<tr>
<td>To the building walls with windows</td>
<td>10.0</td>
<td>2.5</td>
</tr>
<tr>
<td>To the walls of the buildings and structures without windows</td>
<td>5.0</td>
<td>2.5</td>
</tr>
<tr>
<td>To the carriageway of the street, kerbstone zone</td>
<td>2.0</td>
<td>1.0</td>
</tr>
<tr>
<td>To light network and trolleybus poles, columns and overhead supports</td>
<td>4.0</td>
<td>–</td>
</tr>
<tr>
<td>To supporting walls or internal edge</td>
<td>3.0</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Distances to overhead power supply lines are calculated according to power supply line engineering norms and special conditions for use of land and forest.

3.2. The sideway green zone

The sideway is a part of the street intended for pedestrians, that is right at the carriageway or separated from the carriageway by the green zone. The sidewalk green zone should be planted taking account of the width of the zone and the function of plants to be carried out on the zone. These zones should consists of trees, and only in individual cases they could consist of trees and bushes or only bushes.

Where the street has an east-west orientation the best plant growth conditions on the building green zone and the sidewalk green zone are on the northern (sunny) side of the street; therefore, on the other side of the street trees and bushes that tolerate the shade should be planted; and where the street has a north-south orientation, then good plant growth conditions are created on both sides of the street [8].

Trees are the main components of the sidewalk green zone, and they should be planted into well prepared soil; under the trees the zone should be sewn with lawn. On the sidewalk green zone the distances between the trees in the line are set taking account of their purpose, breed of trees, width of the leaf and number of lines (Table 2).

Sometimes it is recommended to plant trees at larger distances so that their trimming would be rarer and so that their leaf does not interfere with each other. Intervals between the leaf is recommended to be 1-2 m. Such tree lines look nice on the street. On the green zone near representative buildings, squares, etc., in order to create conditions for a better view of architecture or monumental sculpture objects, openings may be left in the lines by planting small blooming bushes or making flower beds. To avoid monotonic planting of the sidewalk green zones, it is recommended to plant some trees with a different branch systems or with a different colour (red, yellow, mixed, etc.) leaf; such trees should be planted in the places suitable with regard to the arrangement [9].

It is not recommended that trees with surface and well-developed root system are planted on the sidewalk green zone as their rots would ruin street and sidewalk pavements; it is not recommended to plant trees that suffer from treading or mechanical injuries.

If there are no possibilities to make the sidewalk green zones on the streets or their parts, the trees could be planted on the sidewalk leaving 1.5x1.5 m fields that are air and water permeable; the field are covered with metal grid (Figure 5).

Sometimes, to make arrangement diverse, on the streets the sidewalk green zone is made of trees and short or medium height bushes. On such zones the distance between the tree trunk and the bush should be at least 2.0 m. The sidewalk green zone that is located close to the park or square or other green areas could form a follow-up of the landscape; such green zones should have small groups of trees coherent with groups of blooming and colourful bushes. However, on the street side the pavement have to be left open so that people feel safe. Famous Polish urbanist Czarnecki says that on the street the tree leaf should start at the height of 3.2 m of the land surface.

Narrow sideway green zones (0.8-1.5 m wide) could be sewn only with lawn or with lawn with one line of bushes. Planting two lines of bushes, the green zone should be 1.6-3.0 m wide (Table 2).

Planting the bushes on the sidewalk green zone, it is recommended to form simple or mixed groups of freely growing short (0.4-0.7 m) or medium height (0.8-1.0 m) bushes or trimmed hedges. Simple groups consist of one species bushes. Combining two or three simple groups into one arrangement, a combined group is formed. In this composition each group consists of different species bushes. In a similar way a hedge is made. Blooming bushes and bushes with colourful leaves should be planted in well lightened and well seen places [6].

In individual cases, high and very high bushes (up to 2.0 m) could be planted on narrow sideway green zones (3 m). They are planted rhythmically and maintaining 2 m distance between them when they are mature.

Up to 1 m high trimmed hedges could be planted on the sideway green zones [2]. They consist of 2-3 year old homogeneous bushes planted in one, two or three lines. Plants are selected taking account of the desired height and width of the hedge.

The building green zones or the sidewalk green zones could not only be planted but also could contain small architecture objects (kiosks, phone booths, field furniture, flower stands, etc.). They could be used to form a certain view characteristic of the territory. it is very important that these objects are selected or designed in a complex way and form a stylistic unity. These complexes should be chosen of a unique style street, part or the street, etc. [10].
Table 2. Dependence of the minimal width of the sidewalk green zones on the arrangement solution of plants

<table>
<thead>
<tr>
<th>Type of plant arrangement</th>
<th>Width of the leaf of a mature tree, m</th>
<th>Distances between planting centre-lines, m</th>
<th>Minima 1 width of zone, m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tree line:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>one</td>
<td>4.0</td>
<td>6.0</td>
<td>2.0</td>
</tr>
<tr>
<td>two</td>
<td>6.0</td>
<td>8.0–10.0</td>
<td>5.0</td>
</tr>
<tr>
<td></td>
<td>4.0</td>
<td>6.0</td>
<td>7.0–8.0</td>
</tr>
<tr>
<td>Small groups of trees and bushes:</td>
<td>according to arrangement solution</td>
<td>according to arrangement solution</td>
<td>7.0–8.0</td>
</tr>
<tr>
<td>a group of three trees</td>
<td>–</td>
<td>–</td>
<td>7.0–8.0</td>
</tr>
<tr>
<td>a group of a tree and bushes</td>
<td>–</td>
<td>–</td>
<td>8.0–10.0</td>
</tr>
<tr>
<td>a group of three trees and bushes</td>
<td>according to arrangement solution</td>
<td>according to arrangement solution</td>
<td>1.6–3.0</td>
</tr>
<tr>
<td>Lines and groups of bushes:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>one line of freely growing bushes or a hedge (up to 1 m high)</td>
<td>2 m gaps are left every 4 m</td>
<td>0,8–1,5</td>
<td></td>
</tr>
<tr>
<td>groups of bushes</td>
<td>according to arrangement solution</td>
<td>according to arrangement solution</td>
<td>1.6–3.0</td>
</tr>
</tbody>
</table>

In the Western countries special attention is devoted to the small architecture on the places where suburban roads merge with urban streets so that a driver sees that a residential area started [11].

3.3. Central separating green zone

The central separating green zone is the central separating zone between opposite direction traffic lanes. Their width depends on the street category and its planned spatial solution.

To ensure traffic safety, 6-meter wide central separating green zone is built along the street of category A; and 3.5-meter wide central separating green zone is built along the street of category B. The central separating green zones are sewn with lawn, and lawn may be planted with longitudinal, transverse or diagonal lines of freely growing or trimmed hedge, groups freely arranged or trimmed bushes consisting of 2-3 bushes, and their height should not exceed 0.7 m to form a field of good visibility. Out of town, where the street is not illuminated at night, hedges should be planted to protect drivers from dazzling line; such hedge should be at least 1.5 m high.

3.4. Intersection green zones and isles

An intersection is a junction of several streets, including their carriageway, sidewalks, bicycle tracks, green areas and other territories. The intersection green zone plays an important role on the intersection. These are plants of the sidewalk green zone and the intersection green isles getting into the visibility area when approaching the intersection (Figure 7).

Fig 7. Plants on the intersection plant zones, formed taking account of the visibility area: a – the intersection of category C streets; b – T form of category B and C streets.

The visibility area should contain any obstacles, therefore it is recommended to sewn simple lawn or sometimes put flower beds (not exceeding 0.7 m). The visibility area depends on the category of the streets joining in the intersection (carriageway width, m), intersection type, permitted speed (km/h), transport mode, flow sizes, planned solution of the intersection, etc. More possibilities are available when planting the intersection green isles. Different type and form intersection isles are called the intersection green isles. They are usually sewn with lawn, and lawn may have decorative bushes and single narrow leaf trees unless they get within the limits of the visibility area. It is recommended that conifer bushes (mountain pines (pinus mugo), savins (juniperus sabina), etc.) and conifer trees (white spruces (picea glauca), blue spruce (picea pungens), black pine (pinus nigra), Coast Douglas-fir (Pseudotsuga menziesii), etc.) are planted there. The intersection isles located in the representative parts of the town could contain annual or perennial flower beds. Flower beds are seen from a moving vehicle so their form and design should be simple, colours of flowers are bright and contrast arrangement are formed (Figure 8).
3.5. Special green zone of underground engineering networks

Planting of trees and bushes is not allowed on the special green zone of underground engineering networks of urban streets; this zone is usually sewn with lawn. On urban streets, the sideway green zones is usually built near the special green zones of underground engineering networks, or underground engineering networks are located in the urban territories that are planned to be planted, therefore, in all of these cases it is necessary to observe minimal normative distances between trees or bushes and underground engineering networks.

Table 3. Minimal distances between trees/bushes and underground engineering networks

<table>
<thead>
<tr>
<th>Underground engineering networks</th>
<th>Distance to the centre-line, m</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>from the tree trunk</td>
</tr>
<tr>
<td>To wastewater pipeline</td>
<td>2,0</td>
</tr>
<tr>
<td>To water-supply pipeline</td>
<td>2,0</td>
</tr>
<tr>
<td>To gas pipeline</td>
<td>2,5</td>
</tr>
<tr>
<td>To heat pipeline or channel wall</td>
<td>2,0</td>
</tr>
<tr>
<td>To power supply or communication cable</td>
<td>2,0</td>
</tr>
</tbody>
</table>

3.6. Protective green zone.

To protect against air pollution, the so-called protective green zones should be built along the carriageway of the street of category A, and sometimes along the street of category B where norms are exceeded their and no other measures are applied. Their width should be minimal so that this zone is ventilated and does not need much investment and care, also that it is efficient not only in summer but also in winter when trees are leafless.

It is recommended that the protective plant zones are dense and wind resistant. The minimal width of the protective green zone is 10 m; it should consist of 5 lines of trees and bushes with 3-meter gaps between the lines of trees and 1.5-2.0-meter gaps between the lines of bushes. It is recommended that the cross-section of the line is of a triangle form. The protective green zone of such construction is well-protected from emissions and dust, and reduces noise. Therefore, 1 line of high trees is planted on the centre-line of the zone, and then 1 line of shorter trees and 1 line of medium height bushes are planted near it.

The optimal green zone is 20-25 m high, dense and triangle zone consisting of 7-9 lines of trees and bushes with tree lines being planted every 3-4 metres, and bush lines being planted every 1.5-2.5 meters. Such distances are also maintained in the line between trees and bushes. Three lines of high trees are planted on the centre-line of the zone, then 1 line of shorter trees and 1 line of medium height bushes are planted on both sides of it (Figure 9).

Fast growing, emission resistant, dense leaf trees and bushes are selected for the protective green zone.

4. Conclusions

1. The carried out analysis of the existing state of urban streets shows that the planning nature of street plant areas, dimensions of the elements of the planted areas sometimes are determined without taking account of the following: natural climatic conditions of a location; position and functions of the street in the planned urban spatial structure; the street category (changes in the carriage way and in other elements of the street); the existing and forecasted traffic intensity; the level of noise and air pollution; the size of pedestrian flows; the needs of disabled people; the position of the street with regard to cardinal points; the proportion with regard to neighbouring buildings and their characteristic features; the layout of street lights and traffic-lights; the impact of plants (trees, bushes) on safe traffic, clear visibility, comfortable maintenance of the street, protection of pedestrians from possible violence, creation of uniform style of the small architecture and formation of distinctive architectural style, etc. This happens because there are not specialised norms and construction rules that regulate designing of street green areas.

2. A plant area of the street is a whole of planned and planted (with trees, bushes, flowers and grass) areas of the street ensuring normal functioning of traffic, meeting pedestrian needs and forming aesthetic environment.
3. Depending on the street category and the role of the street in the planned spatial structure of the town, the urban street plant area consists of separate green elements of the street: the building green zone; the sidewalk green zone; central separating green zone; intersection green zones and isles; the special green zone of underground engineering networks and the protective green zone. The principles of formation of these green area elements depend on their functions, aesthetical and economic factors that ensure the purpose of the street in the planned spatial structure of the town.

4. Individual street elements should not only be functional but they also have to be aesthetic and economic and to form a uniform view of the street.

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