(LID) PRACTICE: USE OF PERMEABLE MATERIALS ON URBAN AREAS OF NOVI SAD

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Summary: *Urban areas, by definition, for the most are largely areas where impervious surfaces such as streets, sidewalks and parking lots, dominate. These surfaces can be defined as a physical barrier to the passage of water, or lack of infiltration into the soil, and with increasing urbanization, the percentage of „sealed" impervious surfaces also grows. Water that flows through the streets, sidewalks and parking lots, after the rains of high intensity, usually brings a lot of potentially dangerous chemicals and other harmful substances, which is then transmitted through the sewer system and discharged into rivers, lakes and seas. Water that occurs after heavy rains, is a constant source of pollution. The rate of runoff water, generated after the precipitation is influenced by many factors, such as: soil type, water permeability, cross-section and roughness of the final layer of the pavement, climatic factors (evaporation, transpiration), vegetation cover, etc. Permeable materials are widely applied as part of an integrated, multidisciplinary approach to the management of rain runoff, Water-Sensitive Urban Design (WSUD) and Low Impact Development (LID). The streets and parking lots, as the highest percentage of impermeable surfaces in Novi Sad, during high intensity rainfall, often retain water, becoming non-functional. As one of the elements of sustainable eco-materials, permeable surfaces can be applied in urban areas of Novi Sad as a pavement for: pedestrian paths, sidewalks, driveway, parking lots and pavements, for parts of the town with lower traffic intensity. The paper will present the problem of water retention at some locations in Novi Sad during the heavy rains and the possibility of applying different permeable materials as part of Low Impact Development practice, in order to reduce the negative impact of urbanization.*

Keywords: *permeable materials, LID, runoff, Novi Sad*

1. INTRODUCTION

Permeable or porous materials, are some of the environmentally friendly materials, which are increasingly used within the LID (Low Impact Development) practice. LID as a model, describes approaches for planning and design of sustainable drainage systems, while

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minimising pollution and managing the impact on water quality of local water bodies. A similar approach to LID, WSUD (Water Sensitive Urban Design) particularly applied in Australia, is a philosophical approach for urban planning and design that aims to minimise the hydrological impacts of urban development on the surrounding environment [1]. As part of the stormwater managment system, porous concrete was developed in the U.S. by the Florida Concrete Association in the 1970s [2]. From the beginning of their implementation, porous pavements have been called "the holy grail of environmental site design" and "potentially the most important development in urban watersheds since the invention of the automobile". They are the most radical, the most controversial, but also the fastest way for the reconstruction and improvement of impervious surfaces in urban areas [3]. Although permeable pavements are the dominantly applied for pervious concrete in the U.S., they have been used as a material for many years in Europe [4]. Today, the use of porous materials is growing rapidly.

2. POROUS MATERIALS IN URBAN CONDITIONS AND POSITIVE SIDE OF THEIR APPLICATION

By definition, urban areas are largely dominated by impermeable surfaces such as streets, sidewalks and parking lots, which have significant adverse impacts on the water cycle. These surfaces can be defined as a physical barrier to the passage of water ie. the impossibility of water infiltration into the soil. The natural processes of infiltration into groundwater, and evaporation back into the atmosphere, are reduced or eliminated and, as a result, there is often an unnaturally large amount of excess water following rain storms, causing the flooding problems [5]. Permeable surfaces are designed to infiltrate falling rainfall directly onto the surface, by capturing and percolating it into the ground, therby reducing stormwater runoff and recharging groundwater. Depending on design, soil type and rainfall intensity, permeable paving can infiltrate up to 70% to 80% of annual rainfall [6].

Many studies and researches have confirmed that the contaminants from rain runoff are retained in the surface layer and permeable concrete system. Attached pollutants and harmful metals from roads, such as cadmium and lead, are directly collected from rainfall on the porous pavement area and treated through filtration, absorption, and other microbial degradation actions in the subgrade [7]. During a rain event, stormwater flows through the porous surface, drains into the crushed stone sub-base beneath the pavement, and remains stored until stormwater can infiltrate into the soil or, in the case of detention, until it can overflow into a specified drainage outlet. As Urban Water Resource Research Center [8] pointed out, it is estimated that the total amount of phosphorus (P) absorbed by porous materials, is up to 80%, nitrogen (N) in the amount fom 59% to 81%, and reduce of rain runoff has been estimated in the amount from 45% to 75%. Capturing pollutants, prevents negative impacts on the environment. At the newly constructed roads, permeable materials effectively reduce the noise and minimize the effects of splashes and spray of water behind a moving vehicle [9]. Porous pavements can also give urban trees the rooting space they need to grow to their full size. The most commonly applied permeable materials in urban conditions are varieties of permeable asphalt, concrete, and interlocking pavers. Porous asphalt and concrete mixes are similar to their impervious counterparts, but do not include

the finer grade particles [10]. Porous asphalt consists of standard bituminous asphalt in which the fines have been screened and reduced, allowing water to pass through very small voids. Permeable pavers are interlocking units (often concrete) with openings that can be filled with a pervious material such as gravel. Reinforced turf consists of interlocking structural units with openings that can be filled with soil for the growth of turf grass [10,11].

All of this material systems are suitable for parking lots, walkways, sidewalks, basketball courts, and playgrounds. Permeable concrete elements with grooves to connect (Permeable Interlocking Concrete Pavements (PICP)) has joints or openings are filled with permeable material that allows water to infiltrate through a permeable surface.

Pervious paving is primarily used on roadways with low-traffic speeds and volumes, but there are successful examples of pervious asphalt and concrete employed on high-traffic streets [11].

Figure 1. The most commonly applied permeable materials in urban areas: the permeable asphalt/concrete; permeable joint concrete pavers, gravel surface and permeable raster / grass elements

Thanks to the ability of infiltration, soil absorbs water originating from precipitation to its maximum volume. Part of the amount of water evaporates into the atmosphere, while the rest is retained in the soil, ie. in the deeper layers.

The flow of water that exceeds the infiltration capacity of the substrate, is temporarily stored in the cavities of the placenta of permeable pavements, before turning into the substrate (called exfiltration) or prior to release back to the surface runoff through drainage system [12].

Permeable concrete is brighter color than conventional concrete, does not retain heat, thereby lowers the temperature in cities. Reduces noise, due to the large volume between the pores effectively absorb sound, and improves air quality.

In contrast to the smooth surface of conventional concrete, the surface texture of permeable concrete is slightly rougher. Permeable pavements are generally sized to infiltrate a 2-year, 24-hour storm event.

When properly installed and maintained, they should be able to pass a 100-year, 24-hour storm, which requires the construction of overflow or control structures to ensure that the pavement does not saturate and potentially destabilize [13].

Fiure. 2. Cross-section and infiltrative ability of permeable asphalt / concrete

Vegetative roof system is a general term used for any type of roof top greenery. It is defined as an open space covered in plant material, which grows on the top or any other height level of a building. Plants on a green roof can exist only on a certain combination of construction layers and they are planted in substratum, not in soil. In short, vegetative roof system is a roof construction covered in vegetation that lives on the surface [14].
The role of roof gardens consists in delaying the initial time of swelling, due to the absorption of water into the system of roof gardens, reducing the total runoff of rainwater and keeping part of the relatively slow release of excess water that is temporarily stored in the pores of the substrate.
Annually, the retention of rainwater varies from 75% for intensive roof gardens, substrate thickness 150 mm, up to 45% for extensive roof gardens, substrate thickness 100 mm [15]. Permeable nature of the soil, water retention capacity and vegetation cover of the roof is comparable to the meadows.
It is one of the most convincing arguments for the inclusion of green roof systems, as an important element of building infrastructure, for management of stormwater, particularly in densely populated urban areas [16].

3. IMPERMEABLE SURFACES IN NOVI SAD

According to the recommendations of the EU, every city should have between 20% and 25 % of green space, compared to the total area of the city [17]. In the city of Novi Sad, the total amount of green spaces ranges from 5% in the city center, to a maximum of 15 % in suburban areas [18]. Increment of hard surfaces can hardly contribute to the quality and protection of the environment. Consequences of problem of high percentage of impervious surfaces in Novi Sad, can, inter alia, be visible during heavy rainfall, when at many roads and parking lots, the retention of water is present. At the city level of Novi Sad, according to a Study on the impacts of flooding and reducing the runoff of rainwater from urban areas [19] in which is calculated the percentage of imperviousness to all parts of Novi Sad separately (city center, Novo Naselje, Detelinara, Salajka, Telep, Liman), the results show that the largest proportion of impervious surfaces with the amount of 60%, appear in the city center (figure 3).

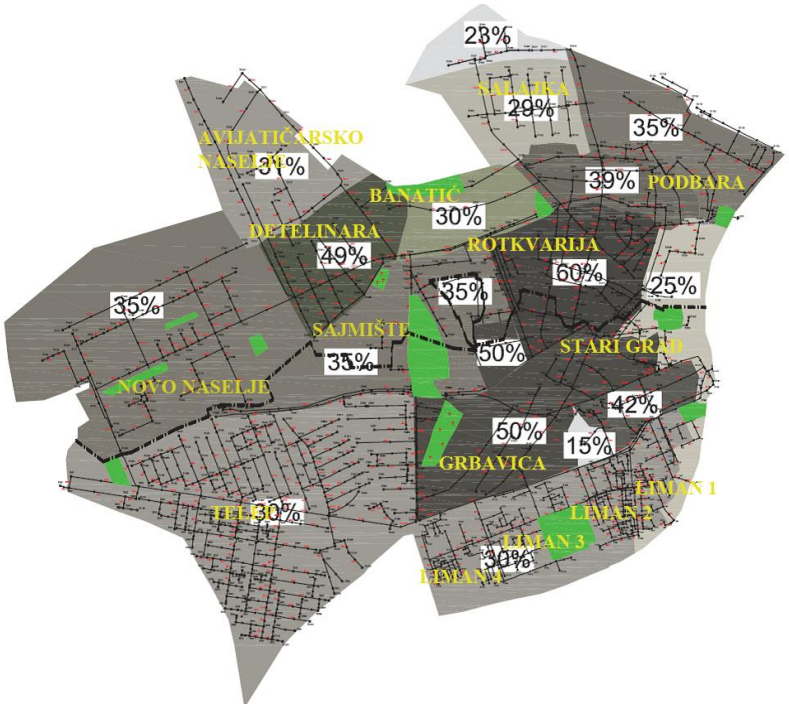

Figure 3. The percentage of impervious surface areas for parts of the Novi Sad city and display of green areas

Water retention in the streets of Novi Sad is present in many parts of the city. It may be noted in figure 4, that these are mainly roads with increased traffic intensity, which results in contamination of that water, and that can seriously affect the city. Most represented impermeable surfaces in Novi Sad, can be classified to roads, parking spaces and roofs of buildings.

Figure 4. Retention of water on the streets of Novi Sad-some of the random locations: (Boulevard despota Stefan, Oslobođenja Boulevard; Jevrejska street)

4. RECOMMENDATIONS FOR APPLICATION OF PERMEABLE MATERIALS IN URBAN CONDITIONS OF NOVI SAD

Permeable systems are suitable for use in different locations and climate conditions. Many authors have dealt with research in terms of survival of permeable pavements and roads in the area where the prevailing low temperatures, but there are positive examples of the implemented permebale systems in Sweden that show that permeable materials are resistant and readily applicable everywhere. The durability of these materials is also evident in the examples of roads in North Carolina, showing their effectiveness more than ten years [20]. On the territory of Novi Sad, permeable pavements can be implemented for parking areas, walkways, sidewalks, plazas, patios and playgrounds. In addition to locations that can be flooded during heavy rainfall, permeable materials may be implemented on every surface that is traditionally paved with an impervious materialas. All permeable materials can function on clay soils [21], which, are also present on the territory of Novi Sad.

Figure 5. Examples of the use of permeable materials in urban areas

It can be concluded that city of Novi Sad has a lot of percentages of impermeability. Permeable materials may be used as a replacement for existing impervious surfaces, or as a metarial for planning or reconstruction of existing roads. Future function of spaces will determine the type of permeable material that can be applied. Permeable materials can be the one of the primary solutions for locations in the city with large amounts of water after heavy rains, highlighted in figure 4. The function of the future, porous space, therefore, can be divided into "passive" and "active". Passive, as paving which will absorb the whole amount of the first rainfall and immediately infiltrate it into the soil and active as paving for absorbing rainfall and keeping it in pavement layers in a limited capacity, together with all the pollutants. Permeable materials can be long-lasting. Routine maintenance, at least once a year, includes surface cleaning, using industrial vacuum, in order to absorb the accumulated particles and sediment, unwanted sludge and compost, for avoiding the closing of pavement pores. To be able to achieve high-quality environmental conditions, it is necessary to take into account the deployment and purpose of new buildings and areas on the city level, as well as the choise of pavement. Proper selection of permeable material

for all types of surfaces, especially for roads, parkings and pedestrian communication, should become a common, sustainable practice.

5. CONCLUSION

With further urbanization and the construction of Novi Sad, the percentage of impervious surfaces will also increase. Precipitation, which are due to climate change, more frequent and higher, will cause non-functionality of urban surfaces, which can lead to large-scale damage. Analyzing the results of a study on the amount of impervious surfaces in Novi Sad, as well as cases of water retention in some locations, it can be concluded that there is a need of a strategic program to adopt new, sustainable technologies in order to replace the existing aproach. Impermeable surfaces and compacted soil in urban areas of Novi Sad are a challenge for the implementation of permeable materials, but their use will significantly improve ecological conditions in the city. Use of ecological and sustainable materials can be an opportunity for environmental rehabilitation, redevelopment and reconstruction of Novi Sad.

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(LID) ПРАКСА: УПОТРЕБА ПРОПУСНИХ МАТЕРИЈАЛА У УРБАНИМ ДЕЛОВИМА НОВОГ САДА

Резиме: *Урбана подручја, по дефиницији, већим делом су простори где преовлађују непропусне површине, као што су улице, тротоари и паркинзи. Ове површине можемо дефинисати као физичку баријеру за пролазак воде, односно немогућност инфилтрирања у тло, а са све већом урбанизацијом, повећава се и проценат „запечаћених", непропусних површина. Вода која тече улицама, тротоарима и паркинзима након киша јаког интензитета, за собом, најчешће, носи и многе потенцијално опасне хемикалије и друге штетне материје, која се затим преноси кроз канализационе системе и на крају испушта у реке, језера и мора. Вода која настаје након јаких киша, представља стални извор загађења. На брзину отицаја воде настале након падавина утичу многи фактори, као што су: врста земљишта,*

водопропусност, пад, попречни пресек и храпавост завршног слоја на засторима, климатски фактори (испаравање, транспирација), биљни покривач итд. Пропусни материјали широко су примењени као део интегралног, мултидисциплинарног приступа управљања кишним отицајем, водо-сензитивног урбаног дизајна (WSUD) и развоја са ниским утицајем (LID). Улице и паркинзи, процентуално највише заступљене непропусне површине у Новом Саду, за време падавина јаког интензитета често задржавају воду и тада су нефункционални. Као један од елемената одрживог градитељства тј. екоматеријала, пропусне површине могу се применити у урбаним деловима Новог Сада као застор за: пешачке стазе, тротоаре, колске прилазе, паркинге и коловозе, односно за делове града са саобраћајем нижег интензитета. У раду ће бити презентован проблем задржавања воде на појединим локацијама у Новом Саду за време јаких киша и могућност примене различитих пропусних материјала, као праксе развоја са ниским утицајем, у циљу умањења негативног утицаја урбанизације.

Кључне речи: *пропусни материјали, LID, отицај, Нови Сад*