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THE CHURCH OF ST. PANTELEIMON IN VELES: ARCHITECTURE, SPATIAL ORGANIZATION AND CONSTRUCTIVE MATERIALS

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Abstract. *The church of St. Panteleimon in Veles is located in the south of the city. Positioned on the right side of the river Vardar, the church is built on a hilly, inaccessible terrain quite unsuitable and difficult for construction. On this specific site the building is erected, placed on an artificially built terrace. With its size dominates the urban milieu of that part of the city. All her splendor and beauty are especially evident when one enters the nave of this monumental edifice, where one fully experiences her magnificence, architectural perfection of proportions and masterful skill in its complete interior and exterior realization.*

Keywords: *Macedonian Revival, 19th century Macedonian Master Builders, 19th Century Macedonia, Sacral Architecture*

1 INTRODUCTION

From the rich opus of its author, master Andreja Damjanov, the church of Saint Panteleimon in Veles stands out as one of the most splendid works of the period of the revival in the Macedonian art, culture, religion. Employing the basilica type as the base in the realization of the architectural plan and the superimposing of the interior galleries, this building marks the beginning of a new era in Macedonian architecture from the 19th century. Undoubtedly, one of the most significant achievements in the sacral architecture was built in 1840, as evident by the inscription placed below the gallery on the west side. On the south entrance Andrjea Damjanov signed himself as the builder of the church.

The church is organized as a three-nave basilica covering an area of 810 square meters however, in its layout it does not represent a typical three-nave basilica. Namely the three-nave naos on both the north and the south side has one extra nave added that function as closed porches, and in fact on the ground floor the architectural plan is solved as a five-nave basilica with clearly differentiated functions. Due to the specificity of the terrain on which the church was built, construction of a west façade was not possible as the church with its western side is attached to a hill. To the east the church ends with three polygonal shaped apses of which the lateral ones are five-sided while the central, the altar apse is six-sided. The highly raised central nave is vaulted with three large domes hidden in the roof structure and completely within the roof of the church. In this way Andreja Damjanov created the system of blind domes that replaced the vaulting with semi cylindrical arches. The side naves however are arched with three-barrel vaults that are transversely grasped by a pair of arcs whose ends terminate at the bottom with a pendant, a type of stalactite considered to be of an oriental influence in the construction of this edifice. The ceilings of the galleries above the side naves are covered with wooden slats, while the upper gallery ceiling on the west side also has somewhat emphasized oriental influences reflected in the frieze of the small, lace like elaborated arcades with pendants.

Andreja Damjanov has in a very skillfully manner delivered his understanding of the inner volume accomplishing it on the principle of superimposing of the galleries. Above the porches (south and north) lie galleries that are overhanging above the central nave and on this floor the church functions as a five-nave structure. On the upper floor the galleries are connected to the one on the west side (the female church), and above it, at the height of the hidden domes of the central nave extends another gallery, with which the building on the west side is elevated vertically on three levels. With this system of superimposing of the galleries, the author sought to achieve a sensational moment in the believer by filling him with a sense of exaltation, ascending and rising him as a Christian to heaven.

The structure is built using combined constructive system of massive masonry and wood where the massive walls are made of stone while the entire vaulted dome construction is wooden. Inside, special attention is paid to the galleries that have adorned plasticity and are decoratively treated combining baroque and oriental forms of decoration. With its size, the interior makes a striking impression. The slender columns, the architectural refinement of the galleries, especially the west side of the nave, the iconostasis and all the other architectural details complement this impression. Decorative ornamentation is used in the decoration of pillars inside the church as well as in the decoration of the exterior of the apse. Damjanov's gift for scenic treating is expressed to maximum in the design of the inner west wall with galleries developing vertically. They are constructed with a complex system of spatial and artistic elements expressed through two baroque balconies, hanging arcades, large and small wooden pillars, carvings, pendants and fences and the east wall with its lavish iconostasis. All this was additionally treated with paintings which give the impression of even greater monumentality.

Contrary the luxurious interior, the exterior of the church is quite simple. The north and south facades are defined by the porch arcades however, the eastern facade is treated with greater attention. Here the apses are made of high-quality limestone that is easy to cut that allowed segmenting these walls with a network of capillaries, blind arcades and niches. The entrance portals are made under the influence of Neo-Baroque and Neo-Byzantine admixtures. Two vaults with a dove above each are placed above the colonnettes framing the portals openings, and over this whole composition there's a niche in which a fresco with the church's patron is painted. In Andreja Damjanov's work certain dose of classical discipline that is particularly emphasized in the clean and precise articulation of horizontal and vertical belts and the established rhythm and dynamics of facade volumes and window openings is evident.

2 ARCHITECTURAL PLAN

The church is designated as a three-nave basilica covering an area of 810 m2, however it does not represent a typical three-nave basilica in its plan. Namely, the three-nave naos on both the north and the south side has one more nave added as porch and thus the building on the ground floor is resolved as a five-nave basilica with clearly differentiated functions (Figure 1). Due to the specificity of the terrain on which it was placed, it was not possible to construct a western façade as the building is leaning on the hill that extends on the same, west side of the church.

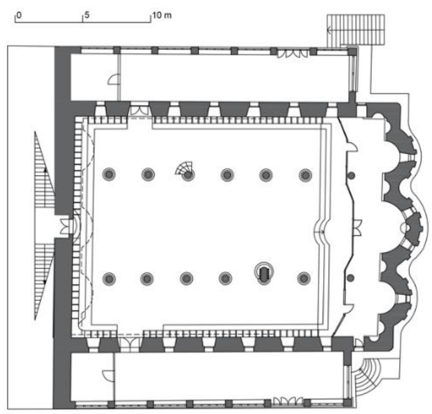

Figure 1. Ground floor (Re-elaborated by Velika Ivkovska; Source: Photo archives of the Institute of History of Architecture and Art, Faculty of Architecture, UKIM, Skopje)

To the east the church ends with three polygonal apses of which the lateral ones are five-sided while the central, altar apse is six-sided (Figure 2).

Figure 2. East façade

The apses, unlike the other two facades, the northern and southern which are plastered and painted, are made with lavish stone decoration. The church has two entrances, one on the south and one on the north side which are accessed through the closed porches on the ground floor. The south and north porch (Figure 3) are raised about 25 centimeters from the surface of the artificially built terrace on which the entire building lies. The dimensions of the interior of these two porches are 17.49 meters in length and 3.5 meters in width.

Figure 3. North porch

The pent roof covering the south and north porch is covered with tiles and is carried by the wall of the upper floor gallery (Figure 4) which on one side is supported by seven stone pillars of the porches that are positioned at a distance of 2.04 meters and have 43cm thickness and the south/north nave wall on the other. The columns are quite modestly elaborated with a square foundation, low base and trapezoidal capital, interconnected with semicircular arcs.

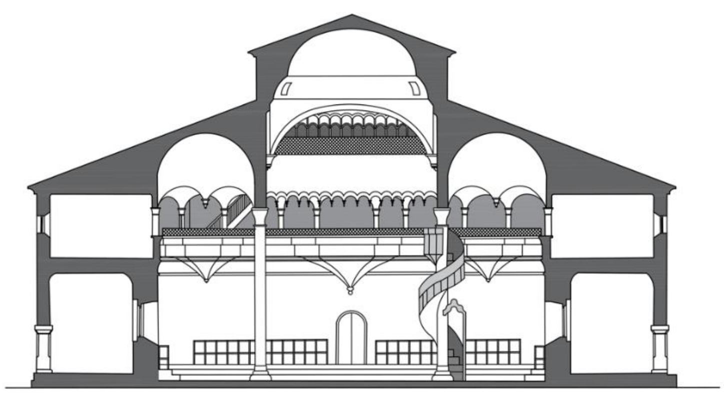

Figure 4. Cross section towards west

The space between the pillars on the porch is closed with glass doors in wooden frames. Above the arches of the porches, on the ground floor in the same plane in height, rises a full wall mass with window openings (Figure 5). To the west of the south and north porch is a 12-square-meter space used for the worshipers' needs. Through the double wooden door on the south wall and two steps, each 25 centimeters high, one enters the naos that is lowered from the level of the porch by 50 centimeters.

Figure 5. South façade

On the ground floor the naos is architecturally resolved as a three-nave basilica with two rows of six pillars in the internal space and one extra pillar in the altar on which the whole iconostasis is supported on.

The central nave (Figure 6) is 7.34 meters wide and 17.78 meters long measured from the stairs on which the solea on the east lies all the way to the stairs on which chairs for the believers are placed. The altar is elevated from the ground level of the nave on 75 centimeters and through 3 steps one reaches the iconostasis which is set at a distance of 2.00 meters from the edge of the solea with an ambo placed right Infront the Royal Doors. Right behind the iconostasis stand the first two pillars, viewed from the altar apse towards west, which define the basilica type plan of the building. These pillars are not additionally decorated and elaborated. Most probably they were not finished because they are immediately right behind the iconostasis on which it rests (hence they are hidden from it). However, it is precisely these pillars that play an important role in ascertaining the internal structure and the way the other pillars in the nave are built which on the other hand are additionally externally elaborated and decorated.

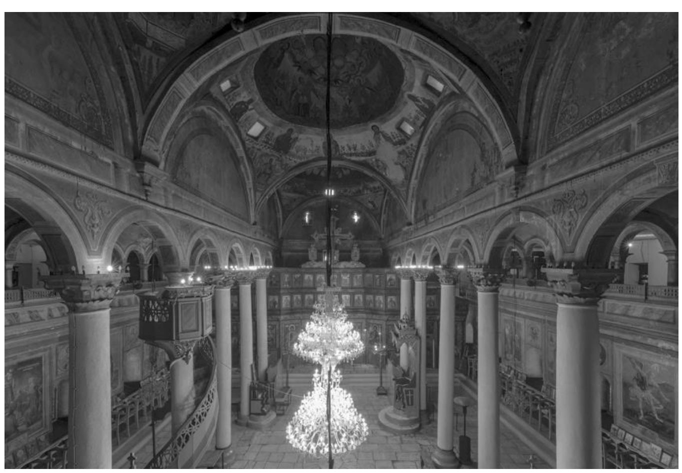

Figure 6. Central nave and view towards the altar

Behind the iconostasis, which lies 2.20 meters from the plane of the east wall, develops the altar space containing the altar apse and two lateral, smaller apses that are 2.40 meters in diameter and 1.15 meters deep. There are two window openings at the altar apse and one on each lateral apse. The central one has a depth of 1.80 meters and a width of 3.80 meters, while the deacon apses are 2.40 meters wide and 1.20 meters deep.

In the corners of the east wall to the north and south there are shallow semicircular niches, those on the east wall are 60 cm deep while those on the north and south 40 cm, all are 90 cm in diameter except that on the south wall with a diameter of 80 cm.

The aisles differ slightly in their dimension measured from the walls to the pillars that separate them from the central nave. The south aisle is 17.74 meters long and 4.25 meters wide while the north one is 17.87 meters long and 4.18 meters wide. There are window openings on the walls on both north and south aisles. These windows are interpolated on the wall so that they come positioned between two pillars of the nave, thus avoiding the possibility that the light entering through them in the nave will be blocked by the placement of the pillars.

On the west side, through two steps leading to a double door, one enters a space containing two pairs of 1.00 m wide single steps leading to the north and south gallery on the upper floor. These stairs are made of stone while the last step leading to the north gallery is made of marble block which is additionally decorated with zoomorphic shapes and a cross placed in a circular rosette.

The complex spatial organization of the interior is emphasized by the side galleries, interconnected with the western gallery above which another gallery is raised. On the north and south wall of the upper floor galleries 6 semicircular windows are placed. At the furthest west point of both north and south wall of the upper floor, there are doors through which one exits from the galleries on the upper floor and through a ramp that follows the slope of the terrain reaches the ground floor of the churchyard.

On the east side of the north and the south gallery there are wooden iconostasis with two rows of icons. On the east wall of these two separate altars there are two semicircular niches above which there is a window with a square opening. On the west side of the gallery there are wooden stairs that lead to the second gallery, which rises at the height of the domes.

The pillars in the nave are connected by semicircular arches above which semicircular niches raise on which a shallow inclined drum with window openings stands. (Figure 7)

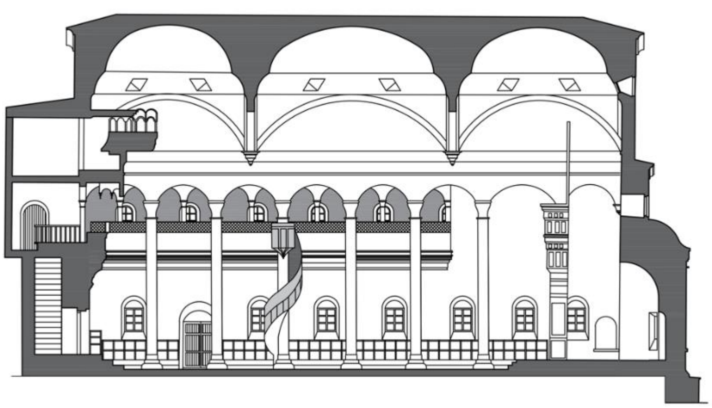

Figure 7. Longitudinal section

The arching of the high-rise central nave is completed with three large domes hidden in the roof structure and completely within the roof of the church. In this way Andreja Damjanov creates the system of blind domes that replaces the surmounting with barrel vaults. The domes lie over nonspecific drums that are quite shallow and cut inwards having small semicircular window openings (Figure 8).

Figure 8. The east and the central dome

The side aisles are covered with three vaulted arches, which are carried on one side on the north and south walls, and on the other side on the semicircular arches connecting the pillars of the central nave. These arches are transversely intertwined with a pair of arches placed between the first and second side aisle bay and placed on the first pillar of the central nave counting from the altar, then on the third, fifth, and seventh pillar, thus grouping two side aisle bay under one barrel vault. The juncture of these double transverse, semicircular arches end at the bottom with a pendant, a type of stalactite that is considered to of be an oriental influence in the construction of this building.

The side naves are covered by a pent roof which also covers the galleries, while the central nave that rises in height above the side naves is covered with roof on four waters over a rectangular basis. The apses are covered with semicircular half domes mounted on drums that are externally decorated.

3 CONSTRUCTIVE SYSTEM

The structure of the building is of combined constructive system of massive masonry and wood. The thick walls are made of stone and brick which are then plastered both from the inside and outside except for the corners of the junction of the south and north façade with the east where the stone outspreads and curves to the roof height of the side nave and east facade with three apses made of hewn limestone. The entire vaulted dome construction is wooden, processed with mesh, plastered and then decorated.

The floor in the naos is made of cut stone blocks. The stairs leading to the first gallery are also made of stone while the floors of the galleries and the stairs leading to the second gallery are made of wooden boards. The roof construction is made of wooden slats that are enclosed in the lower zone with cassette shaped boards and externally covered with roof tiles mounted over the wooden bearing structure.

About the type and the way of constructing the pillars is known from the examination of the condition of the constructing pillars that was made by the Republic Institute for Protection of Monuments of Culture in 1975 and the visible cracks that appeared on one of the pillars when it was uncovered that under the cracked mortar was a second layer of mortar, an older one with no visible damage, and with further probing, examinations and interventions it was concluded how the pillars were made. Namely, the core of the pillar is made of wooden shafts that are surrounded by wooden slats around which a rope-hemp is laid as a base for carrying the mortar and shaping the pillar's circular section. The base of the pillars have circular cross section and at the base are 88cm in diameter, have three profiling heights with a total height of 54cm. Above it is the shaft with 50 cm in diameter and height of 5.7 m and there is a trapezoidal capital that is additionally decorated with zoomorphic motifs made of brass with the exception of the capital of the fifth pillar looking from the apse to the west, and in the north aisle where the ambo is placed, which is not additionally treated, but only painted with oil paint.

The ceilings of the galleries above the side aisles are covered with wooden lattices, but the ceiling of the upper gallery on the west side has emphasized oriental influences which are reflected in the frieze composed of small arcades with pendants. The height of the central dome, measured from the floor of the main nave is 15.50 meters while the other two domes are 15 meters high. The height of the vault above the northern aisle is 9.86 meters, while the height of the southern aisle is 9.99 meters.

4 DECORATION

Three apses made of precisely carved limestone are positioned on the east façade. Due to the possibility of the limestone as material to be handled with ease the apses are decorated and rastered with a network of capitals, blind arcades, niches and end with profiled cornice (Figure 9).

Figure 9. The central apse

The altar apse is six-sided made in limestone that is easy to model. It is divided with seven pilasters that lie in the lower zone on rectangular pedestal with a square section over which the pilasters extend up to 80 cm in height where they are cut with a horizontal cornice with a semicircular section that extends horizontally towards the two lateral apses. These pilasters towards the cornice are connected with semicircular arches that form the profiled cornice under the apses' roof. The pilasters in the upper zone have small capitals with a square section, and above them are semicircular shallow niches formed by the arcs connecting them. The other two lateral apses are elaborated in the same way but because they are smaller are five-sided and divided with six pilasters. Above the cornice, formed by the semicircular arches connecting the pilasters, five-sided drums are raised that carry the roof of the lateral apses, and at the same time raise it to the height of the roof of the central one.

These drums are six-sided, formed by seven shallow pilasters semicircular closed. In the formed fields imitations of window openings are painted. In the central, altar apse, in the space between the pilasters in the upper zone shallow semicircular niches are placed with two window openings located in the second and fifth field formed by the pilasters. Above the two niches of the altar apse are decorative crosses made of limestone in shallow relief and colored in blue. The same niches appear at both lateral apses except that, since the apses are five-sided, in the middle field window opening closed with frames is placed, while the remaining four fields of the apses are enriched with shallow niches. Above these windows decorative cross also made of limestone and colored blue is placed.

The rest of the wall mass extending over the apse is painted white with the exception of the corners where there is a part of the stone from which the walls were built as a form of decoration. The assumption that this decoration may have occurred at a later time by simply removing part of the facade cover is excluded because, after thoroughly analyzing the building and specifically this detail, it is obvious that the stone was left unworked at the time of building because it extruded out of the vertical surface compared to the rest of the plastered façade surface mass. If a part of the facade plaster was removed later, in order to show these stone parts of the walls, it should have been few centimeters pulled from the plaster plane as removed, and not extruded as is the case here so it is easy to conclude that the eastern portions of the façade and the apses were finished with limestone, and the rest of the façade mass to the east, that is, the apse roofs and the east wall of the elevated central nave were plastered and painted. However, on the north and south sides in the altar zone from the outside, it is noticed that the mortar from the façade is extruded from the plane of the stone wall, so it may be assumed that in this area the mortar was likely removed later in order to achieve additional decoration in this part of the south and north facade of the nave although the very angles of the eastern facade with the north and south of the nave have been treated and semi circularly cut to the roof at the height of the half domes of the apses on the southern facade.

On the eastern facade above the apses there are three openings. At the head of each nave of the interior, and at height of the attic space of the upper floor galleries. The side windows of this façade that are positioned in the galleries are drawn back from the plane of the east façade towards the west up to the plane of the platform on which in the interior the altar space is raised. They have a four-leaf clover shape and illuminate the small altar spaces that are positioned on the upper galleries. On both side naves of the east façade identical windows are placed. In square fields windows in the shape of a cross are placed and are smaller in size than the window placed on the central nave of the east façade above the dome of the apse. Since the central nave is higher than the lateral ones, which is legible on the eastern façade, also here below the dome space three windows are placed of which the central one is higher because it is placed on the angled drum of the first dome, while the two lateral ones are set in the semicircular niche that closes from inside the central nave right above the semi dome of the altar apse. These windows also are in the shape of a cross.

The eastern facade on the north and south porches on the ground floor is closed with one glass door in a wooden frame with a semicircular arch, identical to the rest of the window doors of the porches. Above these doors on the east facades of the upper galleries four-leaf clover windows are opened. The corners of the east facade of the upper galleries with the north and south facades are colored with horizontal lines in gray and brown color.

The South and the North Façades are identically elaborated and decorated. On the ground floor there are porches formed of seven square stone pillars set at a distance of 2.04 meters and a thickness of 43 cm. The columns are quite modestly elaborated with a square section, low base and trapezoidal capital, interconnected with semicircular arches. The space between the pillars on the porch is closed with glass doors in wooden frames. Above the arches of the porches, on the ground floor, in the same plane, rises a full wall to which the south and north gallery with window openings are located. The facades note that these windows are not arranged under any rhythm or symmetry following an analogy of the porches beneath them, since their placement does not correspond to the pillar grid and the grid of the arches of the porch on the ground floor. On the inside of the galleries these windows have an 80cm light opening and a 135cm inner opening. The parapet measured from the gallery floor has a height of 95 centimeters, then tilts at a 45-degree angle to the wall and reaches a height of 120 centimeters, ending at the upper horizontal with a semicircular arch.

On the ground floor of the north and south wall of the side aisles, oriented to the closed porches windows that illuminate the ground floor of the nave through the light coming from the two side porches to the north and south are positioned. These windows are 120 cm high and 70cm wide, mounted on a 170cm parapet, measured from the floor of the nave which then cuts to a height of 210cm on the wall which is 100cm thick. They are enclosed with metal bars and glass and are mounted on a wall. The upper zones of the windows are semi circularly arched. From the outside to the porches these windows have a decorative, profiled limestone frame. As the central nave rises above the side aisles, six windows are placed, which are actually the windows placed on the shallow inclined drums of the semi domes. They are completed in a circular field with cross-shaped openings.

On the north and south facades of the nave in a section not covered by porches, which corresponds to the altar space of the interior is a wooden door with a semicircular frieze made of stone. On the floor of the north and south façade of the far west side, there is also a wooden door leading directly out of the building where through the earthen ramp cut into the terrain one reaches the ground level of the churchyard.

In the church special attention is paid to the elaboration of the portals that contain vegetal relief plastic combined with zoomorphic plastic. Baroque forms are visible presenting meticulous and precise stone carving. The profiles are pedantically completed just like the various depictions of fantastic animals. The entrance portals, north and south, are treated in relief with neo-Baroque and neo-Byzantine origins. Above the colonnades framing the openings are two curved S vaults with a dove on each, and over this whole composition a niche is sculptured where the fresco of the church patron is placed. Damjanov engraved his name on the southern portal with the following text:

Маистро андреiа щоправi црквата

In the interior, special attention is paid to the decoration of galleries which are richly plastic and decoratively elaborated and are a combination of baroque and oriental forms of decoration. The interior is skillfully designed with a two-story gallery to the west. The emporium of the galleries is richly profiled with colonettes, arches and friezes of painted decoration between the floors and all in a colorful composition of stone in pink, ocher and brick incarnate. With its size interior gives an imposing impression with its slender columns, rich architectural elaboration of galleries, especially the west side of the naos, the iconostasis and the remaining architectural details. This decorative ornamentation is used in the decoration of the pillars inside the church as well as in the decoration of the exterior of the apse.

Damjanov's gift for stage design is expressed to the maximum in the creation of the western wall with the galleries rising vertically. They are made of a complex system of spatial and artistic elements expressed through two baroque bent balconies, small arcade rows, large and small wood carved colons, large pendants, fences, etc. and the east wall with its imposing iconostasis. All this was additionally treated with painting which gave the impression of even greater monumentality.

In terms of the typology of forming the architectural plan typologies specific for the 19th century is that in this era, the era of revival, large-sized basilicas are built. The basic architectural type of plan is the three-nave basilica with porches on the ground floor and upper floor galleries. During the analysis of the architectural plan of the church of St. Panteleimon in Veles it can be concluded that Damjanov inherited the three-nave resolution of the plan specific for the church building in Macedonia and the Balkans in the 19th century, which means that he does not introduce any novelty, but uses what is already present and specific of these regions.

The church of St. Panteleimon in Veles is built as a three-nave structure with clearly defined functions. What is characteristic about it, unlike all the other churches from Damjanov's opus as well as from the works in the Balkans is that the main access to the building is through the north and south porch as the church has no western facade. The reason for this is the specificity of the terrain on which it was built, which is why the whole building to the west is attached to the hill below which the plateau on which the church is built is located. This moment has in fact been imposed as reason that the church does not have a western façade, and from this way of overcoming the natural obstacles and finding a constructively favorable solution for the construction of a large church temple confirms Damjanov as educated and skilled builder capable of handling every kind of problem and give an adequate solution.

What he will first apply in his church in Veles, something we will encounter for the first time in his, as well as in the works in the Balkans, is the formation of a second, western gallery set above the western gallery on the first floor. This innovation is specific and characteristic of Damjanov, it is his recognizable element, the product of his talent. For the first time he will produce such a gallery at the height of the domes only for this building and will not repeat it in any of his later works.

What is novelty from a functional point of view and as an element is only seen in this church is the positioning of the stairs that lead to the galleries on the upper floor. He places them in a separate area on the west side forming a kind of narthex accessed from the central nave. He sets two pairs of stairs that lead straight to the upper north and south gallery. This element as an original one for the first time will appear in this church.

Regarding the spatial organization, Damjanov follows the already present model of organizing three nave basilicas. The only difference here is that the space on the ground floor does not function on the west side from the outside but from the inside by building a closed narthex on the west side of the main nave which is used to establish connection with the upper floors, i.e. the north, south and west galleries. Also, a novelty in the functional organization is the appearance of two sloping ramps which through doors on the north and south walls of the galleries on the first floor lead out of the building and connect it with the churchyard on the ground floor. This element in the functional organization of the space appears only in the church of St. Panteleimon. Neither before nor later in the work of Damjanov, we will not encounter such way of external connection of the upper galleries with the exterior. Although the appearance of these ramps was caused by the conditions of the terrain, Damjanov could have not build ones at all. Here we see his skill in building a church building, which for its time was also a building where attention to the aspects of environmental architecture was paid. Damjanov adapted to the natural conditions, did not destroy the natural configuration of the terrain, but on the contrary skillfully incorporated it in the whole spatial, constructive and functional composition and stood out as an architectural virtuoso, a kind of forerunner of today's landscape architecture.

The structural system and building materials of the nineteenth century are specific and identical for majority of the buildings. Damjanov creates his structures in standardized spans that are already skillfully designed. The wall masses are built of stone while the pillars, domes, drums and pendants are made of wooden construction. Ropes were placed around the wooden beams around the pillars and plastered above, while the flat surfaces were made in the same way, by placing plaster on wooden slats. Damjanov builds the floors on the ground floor from stone blocks, while the floors of the galleries on the upper floors are made of wooden planks.

Specific for the decoration of the facades is that Damjanov for the first time, in addition to the main, altar apse, will equally decoratively treat the smaller deacon apses from the outside. The decorative handling of these apses is made of limestone, however this decoration with thin pilasters and a wreath of bows will also be applied on the other two apses in this building. A novelty in the construction of the apses is that above the polygonal wall of the two smaller and lower apses he places a segmented drum on which he draws imitations of window openings. He will apply this element for the first time here, and the reason for its appearance was primarily from a constructive aspect. Namely, with the help of these drums Damjanov raises the roofs of the two smaller apses and aligns them in height with the roof of the altar apse and in that way allows the roof to extend in the same horizontal plane, also allows continuity of the cornice of the three apses in the same horizontal line. This element also complements the originality of the builder.

The appearance of blind domes erected on a shallow inclined drum is the innovative element of Damjanov that he will apply for the first time here and further on he will continue to implement this way of elaborating the domes in the remaining works of his first phase. He will end using this element in his second phase yet these types of blind domes will be found in many other churches in Macedonia.

With all said and elaborated, the place of the Church of St. Pantelejimon in Veles is more than evident. Here Damjanov showed his knowledge, innovation and all of his creative potential. He used inherited elements from the tradition but thanks to his talent he also introduced original elements, some of which he will continue to use, and some of which he will only use in this church. In that way, Danjanov will determine its place within the frame of his opus as well as in his work in the Balkans. It is one of the capital works of the revival, a work marked as a source of innovation, a work evident by its uniqueness and originality. He builds the church of St. Panteleimon in Veles and with he rises himself to the heights of the Balkan architecture. It, like his other buildings, in its structure contains elements that are the key to connecting the variously upgraded experiences of the epochs and offer an answer for the way of their creative upgrading to the point of designing a recognizable building language.

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"The Architecture and Painting of the Church of Saint Panteleimon in Veles by Andreja Damjanov" published by the author Velika Ivkovska in October 2022

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REFERENCES

1. Хаџиева-Алексиевска Ј., Касапова Е., Архитект Андреја Дамјанов, Скопје, 2001.
2. Хаџиева-Алексиевска Ј., Улогата на Македонските архитекти и уметници во создавањето на дворската архитектонска и сакрална естетика во новосоздадените држави Србија и Црна Гора во XIX век, Македонски фолклор, Скопје, 2009.
3. Хаџиева-Алексиевска., Македонските градители, градителски школи и нивната улога во создавњето на новата архитектонска естетика во преродбенската сакрална архитектура, Историја на културата во Македонија, МАНУ, Скопје, 1995.
4. Балабанов К., А.Николовски, Д. Ќорнаков, Споменици на културата на Македонија, Скопје, 1980.
5. Балабанов К., Македонските зографи и методологијата на нивното образование во периодот на 19 и првите децении на 20 век, Скопје, 2000.
6. Бояджиев С.,Българската архитектура през вековете, Софияа, 1982.
7. Василев А., Български Възрожденски Маѝстори, Софияа, 1965.
8. Грозданов Ц., Уметноста и културата на XIX век во Западна Македонија, МАНУ, Скопје, 2004.
9. Грчев К., Историски и архитектонско стилски одредници во црковното градителство на Андреја Дамјанов, Институт за фолклор Марко Цепенков, Скопје, 2002.
10. Грчев К., Црковното градителство во Македонија 1918–1940, Скопје, 1998.
11. Петровски Б.- Грчев К., Дејноста на Андреја Дамјанов и градителските тајфи во Македонија во XIX и почетокот на XX век, Скопје, 1998.
12. Томовски К., Мајстор Андреја Дамјанов (1813–1878), Скопје, 2000.
13. Томовски К ., Сакралната архитектура во Македонија во XIX век (со посебен осврт на делото на градителот Андреја Дамјанов), Семинар за македонски јазик литература и култура , Охрид, 1991.
14. Tomovski Krum, Master builder Andrea Damjanov, Skopje, 1973
15. Ivkovska, V., An Ottoman Era Town in the Balkans, Routledge, London, 2020.
16. Kadijevic, A., Echoes of Medieval Architecture in the Work of the Master-Builder Andreja Damjanov, Zograf 27, (Beograd 1998—1999)

CONTEMPORARY TENDENCIES OF DESIGNING BUILDING PHOTOVOLTAICS WITH INTEGRATION TO THE ARCHITECTURAL DESIGN

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Abstract. *Solar energy was recognized as one of the most important renewable energy technologies in many countries in the recent years. The renewable technologies achieved an important awareness among architectural engineers, who see the concept of integration of photovoltaic system as a new opportunity for integration in the architectural design. Analysis of urban disposition of the solar radiation in the cities is becoming an important factor in conceptualizing the intersecting systems as a basis for architectural study in the organization and orientation of buildings for optimizing the solar potential. In the beginning of the development of the photovoltaic systems, as a solar power generating renewable technologies, they were analyzed only by electrical energy engineers, which created only standard products with limited design possibilities in terms of patterns, dimensions, texture and colors, so integrated approach with architectural engineers is important sustainable factor for the optimization and sustainability of the architectural design. The recent development of the solar renewable technologies and the PV systems, created a new possibilities for them to be reviewed as architectural elements in the architectural design process by many important international architectural studios. Architects must think of new concepts of integration of the photovotaic systems as architectural elements by creating pixeled photovoltaic module, patterns in monocrystaline cells, as well as using different visible materials, patters, textures and color in the thin film modules of the photovoltaic cells in the composition of the architectural design. This scientific paper will explore the architectural possibilities in the architectural design of building integrated photovoltaics in terms of the functional, constructive and aesthetics formal aspects of using building-integrated photovoltaics in architectural design. Building integrated photovoltaics modules should respond to the technical aspects of the energy production, as well as, be integrated as architectural elements according to the function and the building envelope: adaptive fasade, double fasade, PV shading cladding systems in the architectural buildings.*

Keywords: *Architectural Design, Building Integrated Photovoltaics, Solar Renewable Technology.*

1 SOLAR RENEWABLE ENERGY GENERATED BY PHOTOVOLTAIC MODULES

Photovoltaics as integrated element in Architectural design create a new concept of integrated approach with design consultations with the architectural engineers. They are important sustainable factor for the optimization and sustainability of the architectural design. In the beginning of the development of the photovoltaic systems, as a solar power generating renewable technologies, they were analyzed only by electrical energy engineers, which created only standard products with limited design possibilities in terms of patterns, dimensions, texture and colors.

Solar renewable technologies PV systems, create new possibilities for important International architectural studios to be reviewed as architectural elements in the architectural design process.

Photovoltaic systems can be applied in architectural building in two ways: applied in the existing system as building applied photovoltaics or building integrated photovoltaics when the architects plan to substitute and integrate building element: roof, fasade, shading element, parapet. The architect can also choose the typology, size, color and transparency of the photovoltaic modules. Building integrated photovoltaics have more architectural function to the building, than only energy production.

The economic benefit of installing building integrated photovoltaics is that it will be profitable and it will reduce the distribution and transmission losses in the electricity network. These systems have technical and aesthetic aspects that contribute to creating energy-conscious architecture and urban environment.

Building Integrated photovoltaics modules should correspond to the technical aspects of the energy production, and be integrated as architectural elements according to the function of the building envelope: adaptive fasade, double fasade, PV shading cladding systems in the architectural buildings.

Building Integrated Photovoltaics are defined as photovoltaic modules that have double function: energy and architectural aesthetic function, in order to replace the standard structural elements in the buildings. In this case, there is production of electricity on one side, and on the other side from the architectural aspect there is replacing of the traditional building materials with photovoltaic modules which bring significant savings by replacing building material.

2 PHOTOVOLTAIC PANELS AS ELEMENTS IN THE BUILDING INTEGRATED PHOTOVOLTAICS

Photovoltaic cells are the main integration element in the photovoltaic panels. They have semiconductor materials, that have better efficiency according to their different structures. Silicon is the most used pure semiconductor material for the production of photovoltaic cells in a form of monocrystalline, polycrystalline and amorphous silicon.

There are different types of photovoltaic sells: first generation monocrystalline silicon, second generation amorphous silicon, polycrystalline silicon, cadmium-telluride, copper indium gallium selenide, third generation nanocrystalline solar cells, photoelectrochemical cells, graetzel cells, polymer solar cells, solar cells synthesized in coating and fourth generation hybrid - inorganic solar cells with a polymer matrix

Photovoltaic cells that have the most efficiency are using dark blue anti-reflective material coating. Comparing to them the thin-film modules have lower efficiency, but they are cheaper and require less material in the production. The thin-film modules can be used in industrial buildings and buildings with large areas.

Types of photovoltaic modules that are most frequently used in building photovoltaics are: mono-crystalline, poly-crystalline and thin-film modules, which have different level of light absorption, energy efficiency, manufacturing technology and cost of production. Mono-crystalline modules are highly efficient, as blue black polygons that have efficiency in good light of 15%-20%. Polycristalline are mostly used solar panels, even though they are less efficient. Thin film modules are more flexible and they can be produced in different colors, textures and shapes, as well as that the fact that the material for their production is lower, they are cheaper compared to other types of photovoltaics. Hybrid photovoltaics combine photovoltaic sells with the solar thermal collector, which removes heat and captures the energy.

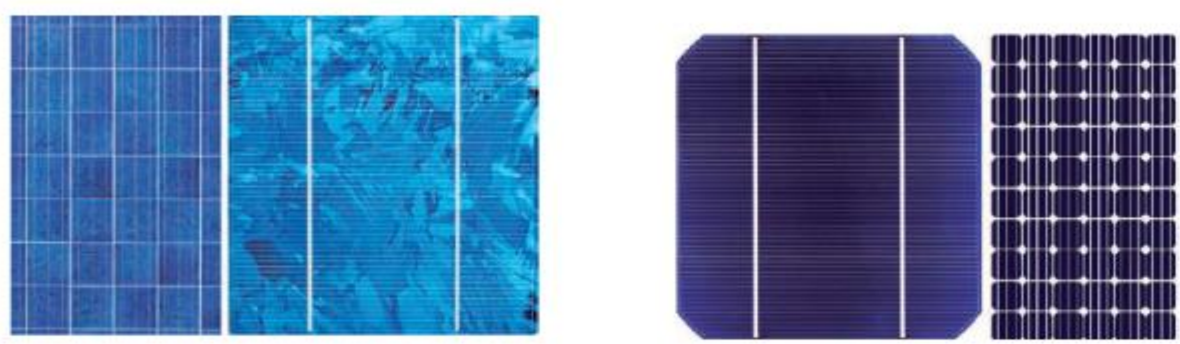

Figure 1. Types of Crystalline PV Cells (Architectural Design Element)

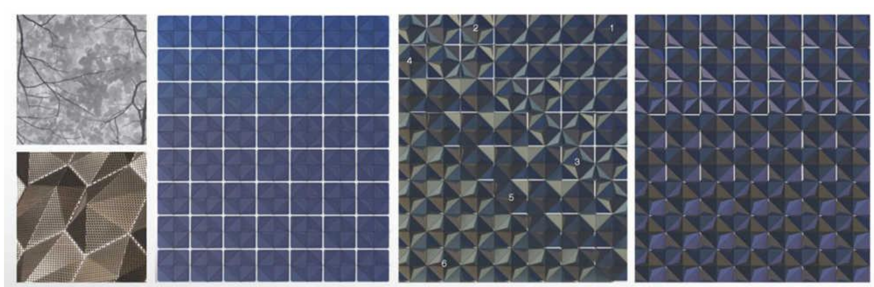

Figure 2. Photovoltaic Panels Patterns with specific architectural design

Figure 3. Architectural Design Element - Photovoltaic Panels Patterns with Photo-printing can be achieved with specific architectural design for the building

Structure of the cells is very important factor in the design of the building integrated photovoltaics. They are available in a different shapes, sizes and models from insulated glass structure to sound iso-glass. The cell has possibility to have natural light enter the building according to the distribution and arrangement of the photovoltaic cells. The arrangement of the photovoltaic cells will contribute to the aesthetic of the architectural design, and will also depend on the density of the cell position in terms of energy production (denser cells will have higher energy production). These types of modules are recommendable in architectural buildings that require high level of integrity and architectural aesthetic design result. Very important factor in the design of the building integrated photovoltaics is the choice of color in the architectural design. Also, important aspect to consider in terms of choosing the color, is that the lighter color of the photovoltaic cells provides lower efficiency in energy production.

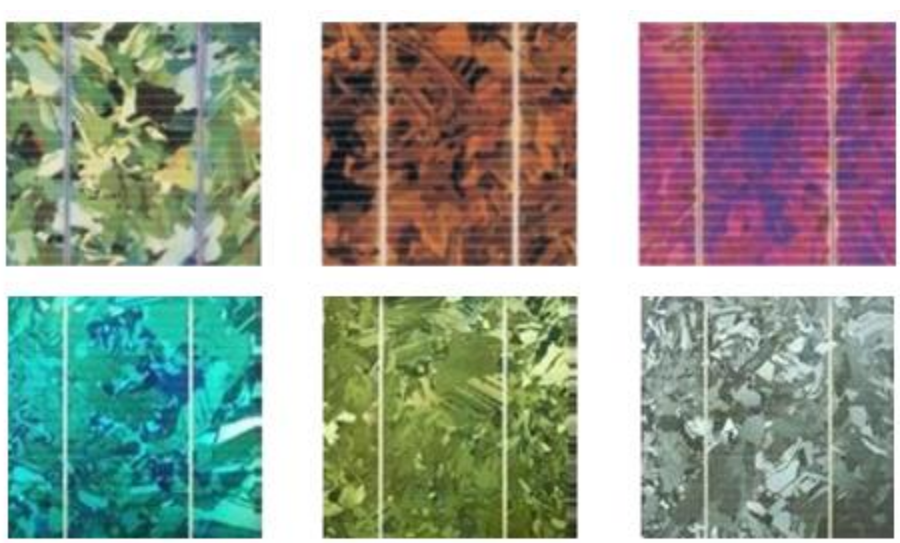

Figure 4. Color varieties in the photovoltaic cells in Solar Innova modules, Source: Solar Innova modules

Integration of photovoltaics can be done in the following building areas: roofs as ideal places for building photovoltaic integration that provide large unused surface, skylights and roofs with glass structure which can create diffuse lighting and can combine photovoltaic installation, fasades which can add the integration of the building photovoltaics in different ways such as glass curtain, ventilated fasade, and other elements such as shading devices that provide shading and aesthetics in the architectural design.

It is very important to have into consideration the fact that the integration of the building photovoltaics should comply to the principle to enable production of electricity and natural light in the building. Also the customized photovoltaic cells, can create interesting light effects in the corridors or interior design in the building as a light and shadow effect.

Even in a situation with a partial shading in the photovoltaic modules, the photovoltaic system is greatly affected in terms of the energy production. In the system of integrated building photovoltaics, special attention should be added in terms of providing adequate ventilation, and this can be solved with a planned ventilated space and space for ventilation between the module. Also, ventilation should be provided for the inverters for optimal usage of the photovoltaic system.

The Photovoltaic system needs to be monitored by the energy technology institutes, which will determine if there is a malfunction in some of the modules which will reduce the overall energy production, identify the irregularities and replace the malfunction of the module. Electrical engineering should provide all technical energy calculations. Also, very important factor is to determine the shades in the photovoltaic system, because they have very important effect in the reduction of the production of electricity.

The Project which will include integrated photovoltaics should analyze both aspects: the production of electricity and the architectural design from the beginning of the architectural project. The project should presented different scenarios with different type of modules in terms of their energy efficiency, architectural aesthetics design and economic aspects of the photovoltaic modules, in order the investor of the project to decide which system will be chosen in a calculations of long-term effects and benefits as a best solution in terms of production of electricity or designing the photovoltaic cells.

The Photovoltaic systems can be also created by adding battery storage units, which can store the accumulated electricity. Integrated building photovoltaics system should also analyze and take into consideration the optimal orientation and angle, as well as the load and stability of the construction of the building. One of the interesting principle of using building integrated photovoltaic systems is that they can be part of circular recycling, and this process can be done in thin film and silicon modules in terms of the materials glass, aluminium and semiconductor materials that they are using, which will reduce their production costs and have positive impact on environment. This principle should be further explored as a possibility by architects and electrical engineers.

3 PHOTOVOLTAIC INTEGRATION PANELS AS ARCHITECTURAL DESIGN ELEMENT (FORMAL AESTHETIC ASPECTS IN ARCHITECTURAL DESIGN BY POSITIONING INTEGRATION OF PV PANELS)

Photovoltaic panels as architectural design element should incorporate the formal aesthetic aspects in the architectural design with the concept of integration of photovoltaic panels according to the International Energy Agency (IEA) as: added technical element, added technical element with double function, free-standing structure, part of surface composition, complete fasade or roof structure or form optimized for solar energy.

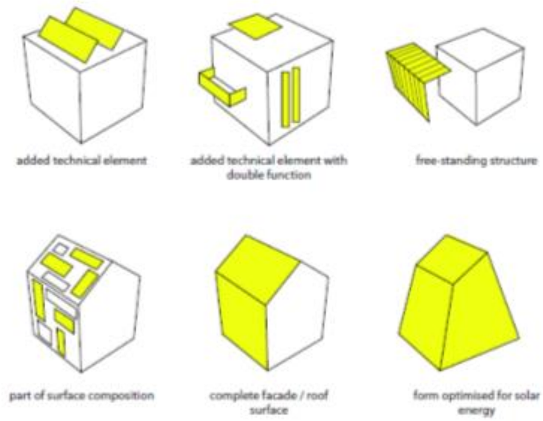

Figure 5. Architectural Design Element- PV Panels, Formal Aesthetic aspects in Architectural Design for positioning and integration of PV panels, Source: Illustration from IEA analysis of positioning and integration of PV Panels, Solar Energy and Architecture, http;//task41.iea-shc.org

The levels of integration of building photovoltaics which can be implemented are: basic, medium and advanced. Basic level requires formal flexibility of the modules, and typically includes retrofit projects. Medium level of integration includes the non-active elements with added function, such as cladding and shading elements. Advanced level of integration provides a complete roof or fasade system that is usually custom-made and includes all interface elements in the photovoltaic systems.

Figure 6. Rooftop with Photovoltaic Panels at the University für Bödenkultur, Vienna, Austria 2016

Roofs are also important architectural element in the application of building integrated photovoltaics. They have great variety of photovoltaics according to color, size, shape and transparency. The photovoltaics can be implemented on the roof with existing structure, or they can be implemented in a photovoltaic roofs which contribute to their efficiency and environmental aspects.

Figure 7. Roof with Photovoltaic Integrated Panels that follow the shape and angle of the roof system

Fasades and skylights provide new aesthetic possibilities to the building. The new innovative technological development leads to integrating building photovoltaics on the building envelope surface.

Building integrated photovoltaics can be implemented in modern architecture as ventilated curtail wall. This system has load-bearing fixing system connected to the building envelope, so the distance between the wall creates space which ventilates the solar modules and creates good insulation layer. Fasades can be designed using different materials with integration to the photovoltaic modules. Ventilated fasades are usually part in the architectural design when there is a need for energy efficient renovation fasade.

Figure 8. Ventilated Fasade as an integrative Photovoltaic Architectural Element

The integration of building photovoltaics into the fasades is achieved in many different solutions, because the fasade is very important architectural design element that is first observed when a visitor approaches the building.

Figure 9. Fasade with integrated PV Panels as Architectural Element

The fasades which use integrated building photovoltaics are multifunctional, on one side they provide production of electricity, create thermal and noise insulation to the building, and on the other side they represent innovation with aesthetic character to the building where the panels become the integral part of the building fasade.

Integrated photovoltaics with the architectural design incorporate the functionality, construction, but also the aesthetics of solar renewable technology. Architects can design fully the shape of the building in accordance to the optimal energy production, The famous architectural slogan from the architect Luis Sullivan "Form Follows Function" is shifting into a new contemporary concept for all architects "Form Follows Energy", which can be seen as a principle in the Energy Base Building in Vienna.

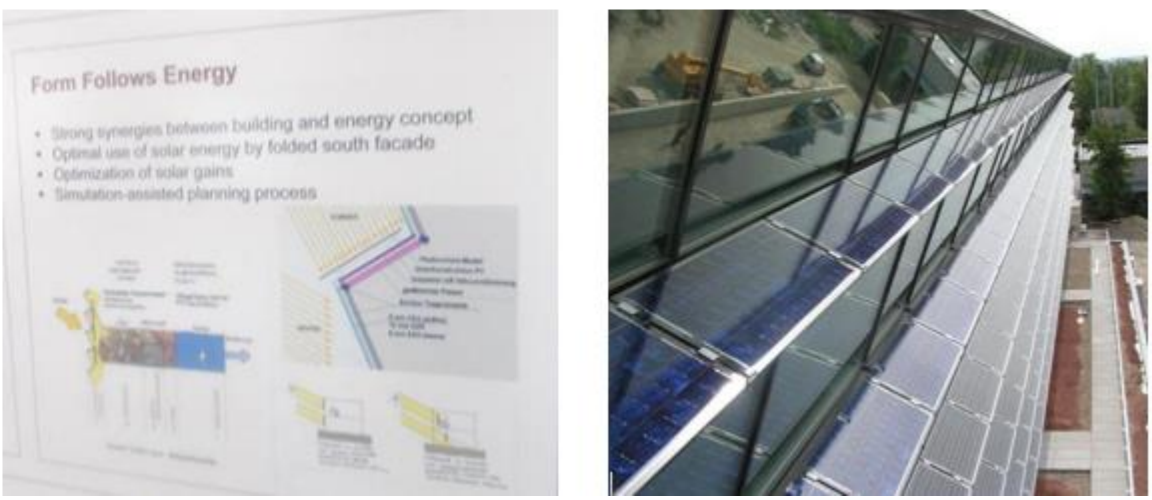

Figure 10. Energy Base Building, Austrian Institute of Technology, Vienna, Austria 2016

The architects have methodology to combine the morphological different shapes, colors and patterns in the building integrated photovoltaics, by approaching the design with customized photovoltaic cells with modern sophisticated renewable design using the photovoltaic technology.

Figure 11. Integrated Building Photovoltaics with different colors, textures and patterns

One of the new innovations in terms of photovoltaics technology is the photovoltaic solar transparent glass, as an innovative high-tech building material which can integrate the solar photovoltaic sell easily in the glass structure while producing energy and have transparent appearance that bring natural light in the building. This system is applicable in architectural design of buildings with different functions, but it is especially recommended in office buildings and buildings with business premises. Main characteristics in the morphological integration of the solar technology that define integration are: the medium for energy production, form of the module, size of the module field, the materials of the module and texture (mono-crystalline silicon), absorption of solar energy, color, size and shape of the modules and type of jointing the modules.

Laminated glass is recommendable and applicable in a cladding glass fasade where the parapet is designed in a safe laminated glass that holds together when it is broken. It is also used in an areas where precautions of high wind resilience is needed. It gives high sound insulation and blocking of most of the UV light. The thickness depends on the regulations. The float glass is a transparent glass that offers high light possibilities and low UV radiation protection. It can be customized in different design pattern according to the needs of the architectural style and the transparency.

Skylights are ideal place for positioning integrated building photovoltaics, because they have slight incline angle, and the photovoltaic panels can create effects of light and shadows providing light in the interior space. Photovoltaic systems in this type of construction are semi-transparent because they allow light inside the building. They provide thermal, solar and sun protection, and selective natural light as semi-transparent photovoltaics, as well as great visual elegant effects in the buildings.

Figure 12. Semi-transparent fasade in Office buildings providing sun-light for the workers in the office building

Shading architectural elements as integrated building photovoltaics are effective and alternative element to generate electricity, which replace traditional elements for shading systems, filter the UV radiation, help raise awareness of the citizens for energy production, integrate renewable energy in urban areas, capitalize from the unused urban structures and create rational economic profitable usage. In this architectural element both aspects are combined: energy production and functional formal aspect of shading.

Figure 13. Shading Systems and Skylight Systems in the Architectural Design of Buildings

Figure 14. Shading Architectural Elements with Photovoltaic Panels

Important possible position of the implementation of integrated building photovoltaics are parking areas, which can contribute directly in charging batteries from the electric cars. The design is typically based on integration of parking modules for two cars with integrated photovoltaics with an incline of 8 degrees for rainfall system. It is very important to design the photovoltaic area with maximum possible energy production, and protection of weather influences: wind, snow and rain weather conditions.

Figure 15. Parking Structures with Photovoltaic Panels that provide shading systems and also functional changing of electro-mobiles

Integrated building photovoltaics can be also implemented in the balcony as an architectural element. This system is particularly recommended when the balcony is highly exposed to sun radiation for optimization of the energy production and to improve its visual elegant appearance. In this situation of the integrated building photovoltaics, it is used multi-layer safety glass with unlimited design possibilities typically in apartment buildings. The photovoltaic modules can be transparent and semi-transparent photovoltaic colored monocrystalline or polycrystalline cells.

Figure 16. Integrated Photovoltaics applied as an architectural element on the Balcony

Integrated building photovoltaics can be also used as architectural element in the acoustic barriers. Photovoltaic solar barriers are very effective in reducing the noise pollution in highways and railways with very high frequencies, with combination of producing energy production. They also have grid-tie economic benefits because they are usually large scale photovoltaic systems that don't need additional land space.

Ground panels with integrated building photovoltaics floor can create sustainable architecture with created unique urban spaces that can generate free electricity, which can have different visual effects of customization with colors and textures. The floor with photovoltaic cells is walkable, have anti-slip structure and supports load efficiency similar to other structural solutions. Sidewalk can also be integrated with photovoltaic floor, that combines the sustainability and architectural function using different colors and textures. The photovoltaic floor is very attractive and can be integrated in any architectural project.

4 INTERNATIONAL ARCHITECTURAL DESIGN STUDIOS INTEGRATE BUILDING PHOTOVOLTAICS IN ARCHITECTURAL DESIGN PROCESS

Architectural Design from famous International Architectural Design Studios such as Zaha Hadid Architects, incorporated custom designed photovoltaic integrated panels that contribute to the design feature as well as to the production of electricity for the sustainable design project: Beijing Daxing International Airport, Zaha Hadid Architects includes photovoltaic power generator.

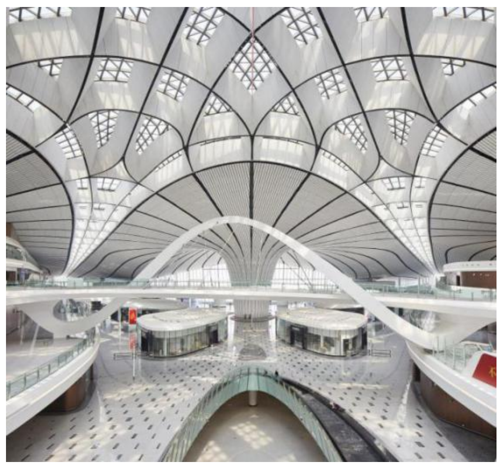

Figure 17. Architectural Design with PV Panels, Beijing Daxing International Airport, Zaha Hadid Architects includes photovoltaic power generator

Figure 18. Architectural Design with PV Panels, Kapsarc, Saudi Arabia, Zaha Hadid Architects

5 ARCHITECTURAL DESIGN STUDIOS INTEGRATE BUILDING PHOTOVOLTAICS IN ARCHITECTURAL DESIGN, DEPARTMENT OF ARCHITECTURE, FACULTY OF ENGINEERING

Architectural Project worked during the architectural design studios in the course Sustainable Architecture at the Faculty of Engineering, Department of Architecture at International Balkan University had several sustainable project objectives: to improve the architectural functioning of the building with implementation of renewable technologies: solar panels, photovoltaic panels, geothermal pumps, green roof system, to improve the connection and between public buildings: municipality building by promoting the use of renewable technologies.

Figure 19. Diploma Architectural Project, Student: Ozcan Kana, Mentor: Assoc. Prof. Dr Viktorija Mangaroska

Figure 20. Diploma Architectural Project, Student: Kubra Hodo Mentor: Assoc. Prof. Dr Viktorija Mangaroska

6 QUALITY STANDARDS IN IMPLEMENTATION OF BUILDING PHOTOVOLTAICS THAT NEED TO BE CONSIDERED IN ARCHITECTURAL DESIGN PROCESS

Integrated building photovoltaics are becoming more important in the field of contemporary sustainable architecture that use new way of application of renewable solar energy. They incorporate the functionality, construction, but also the aesthetics of the renewable technology. The integrated building photovoltaics can be positioned on the building: roof, wall cladding, sun cladding and shadings, additional architectural element - balconies, parapets, and any other architectural element.

The Photovoltaic modules should provide and ensure the highest quality standards in terms of quality, safety and design. The criteria for achieving high architectural quality of the building integrated photovoltaics are defined by the International Energy Agency (IEA) through its Program for Photovoltaic Energy. International Energy Agency Program as the following criteria: "natural integration of PV systems, PV systems that satisfy the architectural context of the building, quality materials and color composition, PV systems that fit well with the existing modular division, visual aspect of the network that is in harmony with the building and makes a good composition, PV systems appropriate for the context of the building and whose integration is well designed, the use of PV systems that challenged the innovative concept." (International Energy Agency Photovoltaic Power Systems Programme).

The standards of implementing building integrated photovoltaics in the building envelope, architects should specifically pay attention to create protection from wind, rain noise and intrusion, provide thermal insulation in cold winter and extreme summer heat, provide regulation for daylight, fresh air and passive solar gains. Special attention should be given in the architectural design of the integration of the photovoltaic modules in the opaque and transparent parts that should provide function of daylight and passive solar thermal gains and visual contact with the outside, and provide natural ventilation. Structural aspects that need to be considered when installing building integrated photovoltaics are to calculate the module load to the load bearing structure, to pay attention to avoid thermal bridges, to pay attention to provide fire protection and weather impacts, and create modules which will resist the wind loads and impacts.

Advantages on using integrated photovoltaics are: energy production, economic investment, reducing the carbon footprint and environmental protection, fasade elements that can have noise reduction and thermal insulation, and saving on the innovative building materials compared to traditional materials. Photovoltaics that are integral system to the building envelope provide clean energy to the building as a cost-effective methodology in the production of energy in architectural design. The produced energy can be used by the building directly without any transportation costs, or it can also be sold to the grid as a grid-tie system. Advantage of the integrated photovoltaics is that they are mostly suitable renewable energy source in cities and urban environment due to the quiet and clean production. Other advantages of the building photovoltaics are: innovation in contemporary and modern architectural design, customization of photovoltaic panels for specific architectural building, integration and aesthetics to the urban environment.

The modules and the photovoltaic solar sells in the integrated photovoltaics can be custom-made according the customer requirements, in terms of different architectural and visual appearance in shape, color, patterns. These building integrated photovoltaics can perform the same function in all areas of the building fasade, compared to standard photovoltaic modules that can be placed only on the flat roof structure in a specific angle.

7 CONCLUSION

Architectural possibilities using building integrated photovoltaics become functional, constructive and aesthetics formal aspects in the architectural design. Architects must think of new concepts of integration of the photovotaic systems as architectural elements by creating pixeled photovoltaic module, patterns in monocrystalline cells, as well as using different visible materials, patters, textures and color in the film modules of the photovoltaic cells in the composition of the architectural design.

Integrated photovoltaics in architectural design studios emerges from the concept of new innovative engineering methods in a stylistic form-based and optimization processes towards new modern contemporary and sustainable style in architecture.

It is becoming very important architectural engineers to have knowledge in the early architectural design phase for better integration of photovoltaics in terms of aesthetic, energetic, constructive and economic aspects in the architectural design of the buildings. Architects should particularly pay attention to the selection of the photovoltaic cells that will bring aesthetic value to the building, as well as the function of the integrated panels, such as thermal insulation, waterproof materials, fire protection, wind protection, acoustic insulation, daylight access, shading, color and transparency of the designed photovoltaics. The importance of use of renewable energy and the reduction of energy consumption, in terms of sustainable modern architecture becomes important factor in their early architectural design phase for many famous architectural studios around the world.

Engineering sustainable concept and paradigm start to shift, in a concept that incorporates contemporary design as a modulation of environments and ecologies in architectural sustainable parametric design of the 21st century. This concept of sustainable design in architecture which incorporated integrated photovoltaics that produce renewable electricity will lead into contemporary transformation of the design process of the next generations of architectural engineers of the 21st century.

Important characteristics that integrated photovoltaics with the architectural design of buildings bring are: improving the citizens' consciousness regarding sustainable renewable energy production, reducing the energy consumption and improving energy efficiency. The decision regarding building project with photovoltaic panels, is defined by several factors such as analysis of energy production, economic aspect and cost estimation, payback period, value and benefits on the energy production and the aesthetic of the building, environmental, social-economic and architectural long-term benefits of the building, photovoltaic cells in relation to their energy production, non-reflective surfaces, maintenance of the structures and possible replacement and recycling.

REFERENCES

1. Abbate, Cinzia (Ed.) "L'integrazione architettonica del fotovoltaico: experienze compiute". "Progetti dal Case Studies report del Task 7, International Energy Agency". Roma: Gangemi Editore. 2002. ISBN 88-492-0336-5
2. Bouwmeester, Henk. "Bouwen op de zon. Eindeloze energie in een duurzame wijk/ Building Solar Suburbs. Renewable energy in a sustainable city". Boxtel: Æneas. 1999. ISBN 90-75365-19-5
3. Integrated Photovoltaic Systems in Buildings, www.gradjenivarsvo.rs .(November 2022)
4. Solar Innova, Katalog Solarni paneli BIPV Personalizirani .(November 2022)
5. Designing Photovoltaic Systems for Architectural Integration, Criteria and Guidelines for product and system developers, Solar Energy and Architecture - International Energy Agency - Solar Heating and Cooling Programme Report T. 41.A.3/2: Task 41 IEA SHC Solar Energy and Architecture, International Energy Agency, 2015 (p. 45-67)
6. Guidelines on building integration of photovoltaic in the Mediterranean area, publication has been produced with the financial assistance of the European Union, ENPI CBC Mediterranean Sea Basin Programme (p. 31-35)
7. Project and Installation of Photovoltaic Systems, Trainee, EU Horizon 2020, 2019
8. Building Integrated Photovoltaics a new opportunity for Architects (p. 21-23)
9. International Energy Agency Photovoltaic Power Systems Programme, https://www.iea.org/reports/solar-pv
10. DGS (Ed.). "Planning and installing photovoltaic systems: a guide for installers, architects and engineers". London: James & James / Earthscan. 2005.
11. Humm, Ottmar; Toggweiler, Peter. "Photovoltaik und Architektur - Die Integration von Solarzellen in Gebäudehüllen". Basel: Birkhäuser. 1993. ISBN 3-7643-2891
12. P. Schumacher, Parametric Order – Architectural Order via an Agent Based Parametric Semiology, published in: Adaptive Ecologies – Correlated Systems of Living by Theodore Spyropoulos, AA Publications, 2013
13. T. Spidelhalter, A. Andia, Post-Parametric Automation in Design and Construction, 2007, pp 58-65
14. Mertins, D. (2006) The Modernity of Zaha Hadid. Departmental Papers of University of Pennsylvania (Architecture), 8, pp.33-38
15. Hagemann, Ingo B. "Gebäudeintegrierte Photovoltaik. Architektonische Integration der Photovoltaik in die Gebäudehülle". Köln, Rudolf Müller. 2002. ISBN 3-481-01776-6
16. Schumacher, P. Parametric Order – Architectural Order via an Agent Based Parametric Semiology, 2013, in Adaptive Ecologies – Correlated Systems of Living,
17. Trends in the Development of Contemporary Residential Building, Stephen George International CEE, Architects,
18. 21st Century Architecture Apartment Building, Images Publishing, 2011
19. Schumacher, P. Parametricism as Style - Parametricist Manifesto. World Architecture, 2009, p.230.
20. Schumacher, P. (2009) Parametricism - A New Global Style for Architecture and Urban Design, in Digital Cities, in Architectural Design, 79

ASSESSMENT OF SUSTAINABLE GREEN URBAN DEVELOPMENT STRATEGIES IN THE CITY OF SKOPJE

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Abstract. *Cities nowadays are facing a number of sustainability challenges in the context of climate change. Cities are vulnerable to the impacts of climate change and the need to connect climate change adaptation and mitigation with broader assessment of sustainability is becoming increasingly important. Urban planners need to plan and create more sustainable and resilient communities, make a plan for climate adaptation, preserve and create green space, adopt green building policies, engage the community in climate change planning process, approach climate change planning on a regional level. The methodology approach in this scientific paper focuses on defining the urban climate adaptation, overcoming urban adaptive capacity aspects and creating urban climate adaptation planning that will be factor for sustainable development in the cities.*

Keywords: *sustainability, urban adaptation, climate change, sustainable development.*

1 CLIMATE CHANGE EFFECTS IN THE CITIES

By 2030 nearly 60 percent of the global population is projected to be urban. Urban centers are drivers of global warming because they concentrate industries, transportation, households and many of the emitters of greenhouse gases (GHG); they are affected by climate change; and they a resources of responses., of initiatives, policies and actions aimed at reducing emissions and adapting to climate change.

Urban areas occupy less than 2% of the Earth's land surface. Urban activities release greenhouse gases (GHGs) that drive global climate change directly (e.g. fossil fuel-based transport) and indirectly (e.g. electricity use and consumption of industrial and agricultural products). 80% of global GHG emissions are estimated to be attributable to urban areas. Cities are also potential hot spots of vulnerability to climate change impacts by virtue of their high concentration of people and assets. Urban areas concentrate population, economic activities and built environments, thus increasing their risk from floods, heat waves, and other climate and weather hazards. Urban centers are drivers of global warming and from the existing data there are three factors as relevant determinants of carbon emissions: a) population, b) affluence as measured by GDP per capita, and c) technology.

Sustainability and resilience can be promoted through a combination of strategies such as integrated urban planning adaptation, building efficiency of urban service quality and promoting green buildings and sustainable transport.

Climate impacts in urban areas and the most pressing issues of relevance to engineers seeking to adapt cities from the following urban climate effects:

- Urban heat islands are caused by the storage of solar energy in the urban fabric during the day and release of this energy into the atmosphere at night: the process of urbanization replaces the cooling effect of vegetated surfaces by imperviously engineered surfaces with different thermal properties.

- Air pollution may increase as warm, still days reduce air quality because high temperatures and ultraviolet light stimulate the production of photochemical smog, ozone and other compounds from traffic and industrial emissions and plants.

- Infrastructure damage from extremes, such as wind storms including hail and storm surges, floods from heavy precipitation events, landslides, tropical cyclones and heat extremes including fires and droughts,

- Biodiversity and urban ecology have already been affected by changes to temperature and precipitation that have resulted in exotic

- Water availability will decrease in many areas, with implications for water resources in terms of both quality and availability for human consumption, industry and agricultural areas.

- Health impacts may include changes to heat- and cold related mortality, food- and water-borne disease from higher average temperatures and/or extreme events.

- The urban economy may be affected in a diversity of ways. Extreme weather-related disasters can be impacted in multiple and complex ways and can take a long time to recover fully. The impacts can lead to direct damage to infrastructure and other urban assets.

2 THE EFFECT OF URBAN HEAT ISLAND IN THE CITIES

The Urban Heat Island mitigation strategies need to provide expertise in various specialized fields, such as urban planning, land use planning, architecture, civil engineering, building engineering, transportation and energy-saving technologies. There are many urban heat island mitigation strategies and they draw on the expertise of various professional fields, including urban planning, architecture, natural resources management and transportation. These mitigation strategies have a positive impact on both local and global climate.

The term Urban Heat Island refers to the observed temperature difference between urban environments and the surrounding rural areas. Urban Heat Island effect is shown on Fig.1, where the day surface temperatures vary widely by surface type and the day air temperatures vary much less. The night surface temperatures are hotter over urban surfaces and the night air temperatures follow the same pattern as surface temperatures.

The Urban Heat Island can have impacts on the environment, such as: deterioration of outdoor air quality, deterioration of indoor air quality, increase in energy demand, increase in demand for potable water; impacts on health, food availability, social impacts, thermal comfort, air conditioning etc.

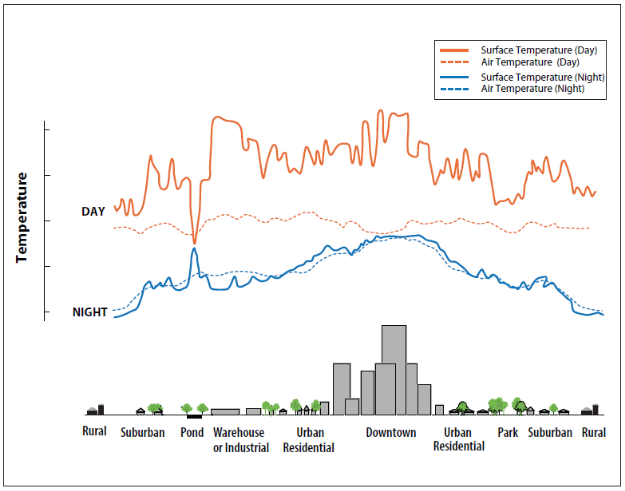


Figure 1. Urban Heat Island – Variations of Surface and Atmospheric Temperatures (Source: Urban Heat Island Basics, 2008, Reducing Urban Heat Islands: Compendium of Strategies, U.S.EPA. p.4)

An urban heat island mitigation strategy must be based on an integrated and multidisciplinary approach, (Fig.2) to urban development and requires the participation of various actors, as well as various sectors, for example public health, urban planning, architecture, transportation and natural resources.

Urban heat island effect in the City Skopje has been analyzed by the Meteorological Center, where the temperature differences in Skopje are within the limits of 1.2 °C to 5.7 °C (Fig 2).

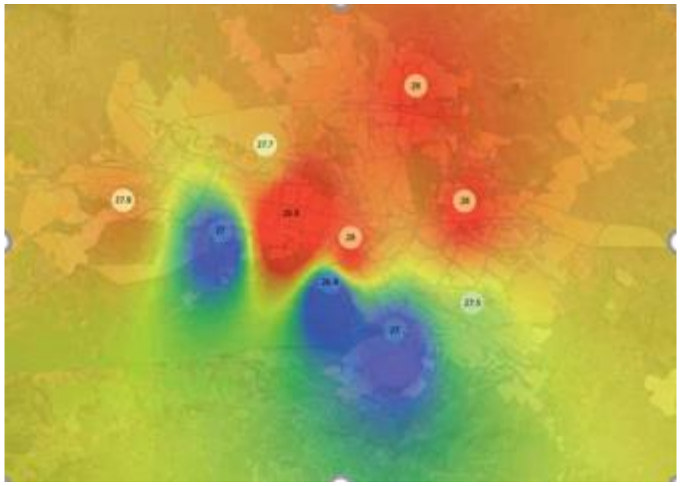


Figure 2. Urban Heat Island in Skopje with interpolation of temperature maps based on temperature measuring in Skopje, Source Resilient Skopje, Climate Change Strategy, 2017

The strategies for reducing Urban Heat Island have benefits for reducing energy demand and source reduction of water and air pollution, including greenhouse gas emissions.

The mitigation measures for reducing urban heat islands can be grouped into three categories (Fig 3):

- Greening measures;
- Urban infrastructure-related measures (architecture and land use planning);
- Anthropogenic heat reduction measures.

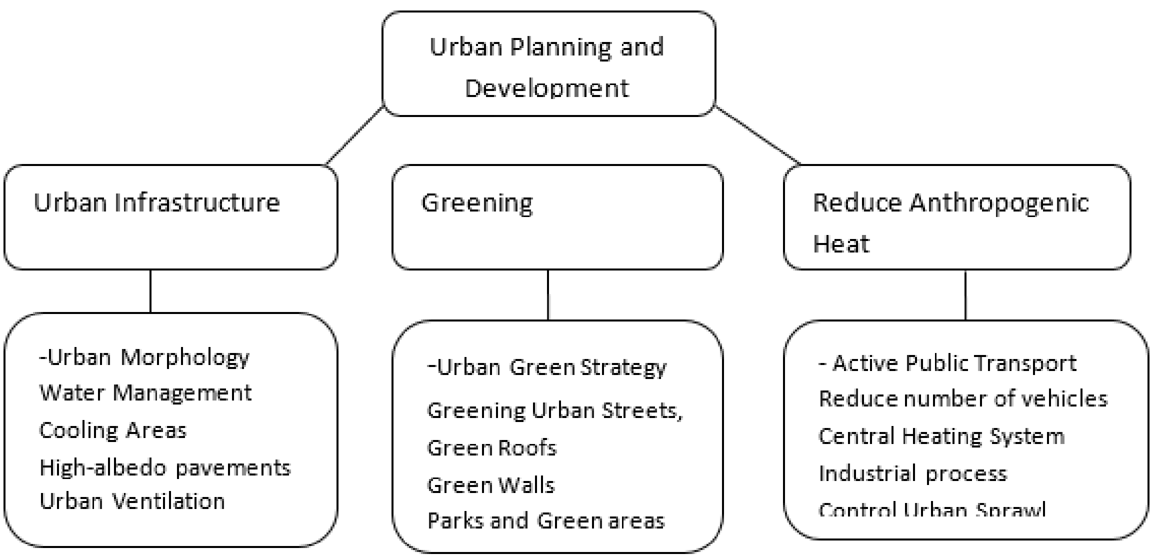


Figure 3. Sustainable organization of Urban Planning and Development in reducing Urban Heat Island

Indicators of environmental quality in the urban green areas in an urban environment, quality of life can be assessed, through indicators that relate to open green areas. Urban environment and the quality of the environment depend on physical conditions and social life. The basic attributes of the physical environment in the city are clean air and the availability of quality water, and it is equally important that the city has provided space and land for green and open spaces. Green areas are considered to be significant indicators of the environmental quality of a city.

a) Environmental functions and benefits for the environment:

- create conditions for protection of natural resources,
- provide habitants and positively affect the diversity of species,
- mitigate the impacts of the urban climate with their regulatory environmental effects,
- emission absorption, noise reduction, reduction of air pollution, and others.

b) Social functions:
- provide a range of recreational activities,
- enhance the quality of life,
- contribute to promote a healthy lifestyle,
- contribute to social integration in the development of communities and provide opportunities for cultural and social events,
- understand the processes in the environment.

c) Economic functions:
- open new businesses,
- strengthen local businesses and economies attracting tourists and investment,
- provide jobs for those who develop, manage and maintain these sites.

d) Functions arising from the planning, development and management of green areas:
- define the urban structure,
- ensure the identity of urban areas,
- contribute to the aesthetic, historical and cultural identity of the city,
- provide balance with the built space and can be developed as a green network that provides contact with nature.

Urban greening strategy and urban climate adaptation planning (Fig.4) provide complementary benefits in urban areas, including:

- Improving air quality through oxygen production, CO2 capture, filtration of suspended particulate matter and reducing energy demand for air conditioning;

- Improving water quality through retention of rainwater in the ground and soil erosion control;

- Health benefits for the population, including protection from ultraviolet (UV) radiation, reducing heat stress and providing spaces for outdoor exercise

- Seasonal shading of infrastructure;

- Evapotranspiration;cooling provided by vegetation (Highly developed urban areas have less surface moisture available for evapotranspiration than natural ground cover. Fig.4)

- Minimizing ground temperature differences.

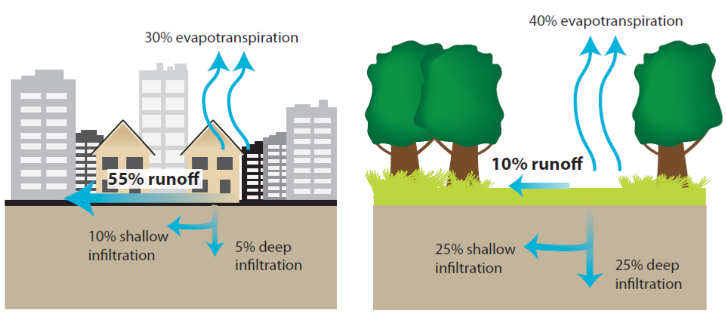


Figure 4. Evapotranspiration on different surfaces of intense urban built environment and vegetation(Source: Urban Heat Island Basics, 2008, Reducing Urban Heat Islands: Compendium of Strategies, U.S.EPA. p.4)

Urban planners and policy decision makers need to plan for sustainable urban development. They need to have holistic approach and integrated urban planning that will focus specifically in reducing urban heat island and climate changes in the cities. Simultaneous use of several urban heat island mitigation measures can have greater impact in lowering urban temperatures. For example, using a combination of complementary measures provides better overall protection of the building envelope from *solar radiation*, which improves thermal comfort in the building.

3 URBAN CLIMATE ADAPTION STRATEGIES IN REPUBLIC OF N. MACEDONIA

Assessments and tools of adaptation strategies need to be predicated on a regional and local level data and assessments. Particularly important are the availability of regional climate change scenarios, risk assessments and modeling, impact Integrated urban planning requires holistic, systems-based analysis that takes into account the quantitative and qualitative costs and benefits of integration com¬pared to stand-alone adaptation and mitigation policies. Analysis should be explicitly framed within local priorities and provide the foun-dation for evidence-based decision support tools. Plans should clarify short, medium and long-term goals, implementa¬tion opportunities, budgets, and concrete measures for assessing progress.

Integrated city climate action plans should include a vari¬ety of mitigation actions: Including energy, transport, waste management, and water policies, and more urban adapta¬tion actions with infrastructure, natural resources, health, and consumption policies in synergis¬tic ways.

The Strategy for sustainable development in Republic of Macedonia includes the following sectors:

- Climate change and clean energy – mitigating climate change and its negative effects on society and the environment through the use of renewable sources of energy and structural change in industry, benefiting facilities that do not have large energy and electricity needs and which have a cumulatively lower impact on the environment;

- Sustainable transport – ensuring that our transport system meets society’s economic, social and environmental needs whilst minimizing its undesirable impacts on the economy, society and the environment;

- Sustainable consumption and production – decoupling economic growth from environmental degradation;

- Conservation and management of natural resources – improving management and avoiding the over exploitation of natural resources, while recognizing the value of ecosystem services.

In the Strategy for sustainable development of the Republic of Macedonia, specific resources have been identified as priorities:

- the natural environment and bio-diversity– improving management and avoiding excessive natural resource exploitation, recognizing the value of ecosystem services, and developing international corridors that secure economic, social and environmental needs;

-Renewable sources of energy– increasing the share of renewable energy use from water, sun, wind and biomass;

- Diversity in traditional high-quality agricultural and forest products– emphasizing organic farming and agriculture, production of healthy food and traditional products such as cheese, wine, honey and spices, and integrated management of agriculture and forestry based on a sustainable economic and environmental approach.

The Green gas emissions scenario in Macedonia is that the total GHG emissions shall increase from 9,030 kt in 2012 to 18,340 kt in 2035, or by 100% (Figure 5).

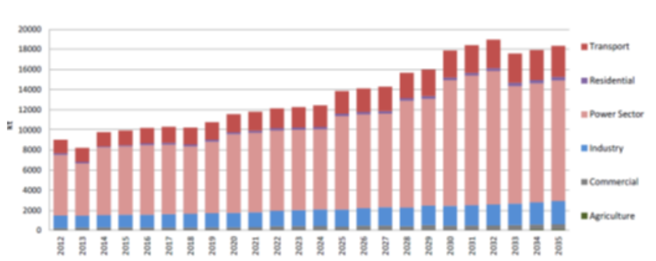


Figure 5. GHG emissions according to WOM scenario Macedonia, (Source: Climate Change Mitigation in Buildings, Transport and Energy Supply Sectors, First Biennial Update Report on Climate Change, Research Center for Energy and Sustainable Development, Macedonian Academy of Sciences and Arts, 2014)

The cumulative CO_2 emissions savings scenario in Macedonia until 2020 amount from 11,000 kt, and by 2030 will increase for five times and amount to 55,000 kt Cumulative emissions, compared to the WOM scenario, by 2020 shall decrease by 12%, while by 2030 they decrease approximately by 22% (Figure 6). The highest reduction is achieved by introducing CO_2 tax and electricity import which generates 34%, and next is the Rulebook on Energy Performance of Buildings with 27%, higher participation of RES with 10% and decreasing losses in distribution with about 6%.

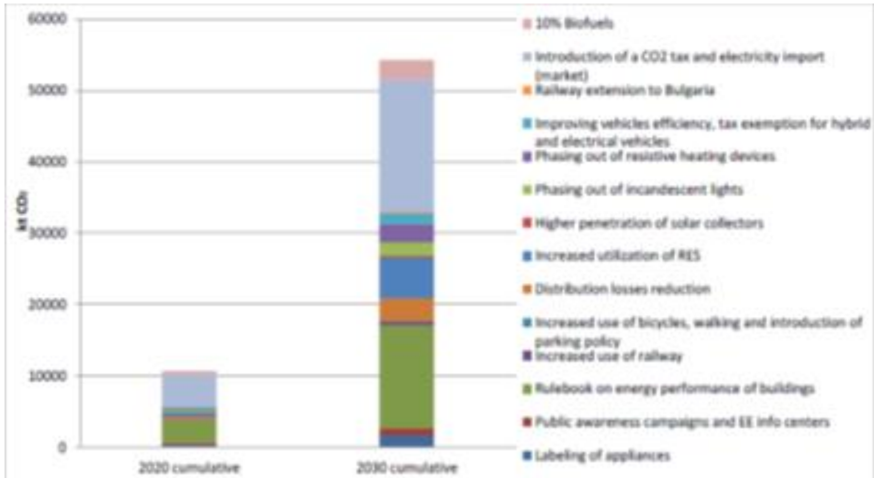


Figure 6. Cumulative savings of CO2 by 2020 and 2030 to WOM scenario Macedonia, (Source: Climate Change Mitigation in Buildings, Transport and Energy Supply Sectors, First Biennial Update Report on Climate Change, Research Center for Energy and Sustainable Development, Macedonian Academy of Sciences and Arts, 2014)

4 GREENING STRATEGIES AND GREEN INFRASTRUCTURE OF THE CITY OF SKOPJE

The methodology and assessment for establishing an integrated green space system is the urban plan. The General Urban Plan provides an integrated system of green spaces, as well as interconnection of the larger urban complexes.

Strategies of development of green spaces in the City of Skopje are defined with the following concepts: defining public open urban space, analysis of the development of the City of Skopje, quantity and quality of urban green area, urban green spaces area in the City of Skopje, defining the green identity of the City of Skopje and planning, development and management of urban green areas.

Greening strategies and Green infrastructure create several benefits in the city such as: social aspects in urban areas, recreational activities, nature and biodiversity, economic aspects: regulation of the solar distribution in buildings, reduction of cooling costs, increasing the economic value of real estate and reducing health costs, aesthetic, historical and cultural identity of the city and defining the green infrastructure in the city.

Greening strategies in the City of Skopje define creating livable green network of streets by planting footpath locations with authentic trees, landscape urban design with greener streets, replacing paving with trees and landscape planting. In the Strategy for greening the region of the City of Skopje, is defined by urban greenery parks, gardens, squares, greenery in residential areas, forests and areas of protected natural landscape, as an integral part of the urban structure. Recommendations for creating a connected network system of urban green spaces and green corridors in the city of Skopje and its surroundings.

Urban Development of the City of Skopje with specific elements of city growth and development of green spaces can be analyzed with the urbanistic plans from 1965 and 1985, but strategies of green spaces are defined more specifically in the general urbanistic plans from 2002 and 2012 year, where recreation green areas and protected green forests in the City of Skopje are defined.

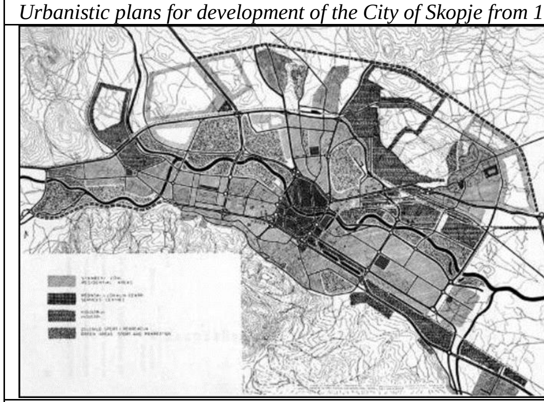
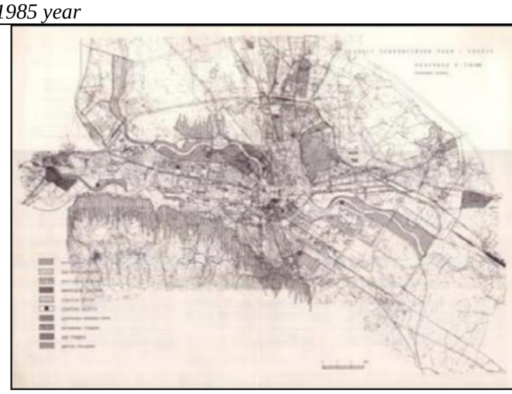
Urbanistic plans and development of the City of Skopje	
Urbanistic plans for development of the City of Skopje from 1965 and 1985 year	
	
Urbanistic plans and development of the City of Skopje	
Urbanistic plans for development of the City of Skopje from 2002 and 2012 year	
	

Table 1. Public Green Spaces in City of Skopje (Source:Студија за озеленување и пошумување на подрачјето на град Скопје, Град Скопје, 2015)

Assessment and condition of green spaces in City of Skopje				
	1964	1985	1998	2011
City green area according to analysis from General Urban Plan in ha	211	426.2	392.9	388
Green spaces in urbanistic scale, maintained by “Parks and Greenery” in city surroundings area in ha	No data	No data	183.2	141
Summary			576.1	529

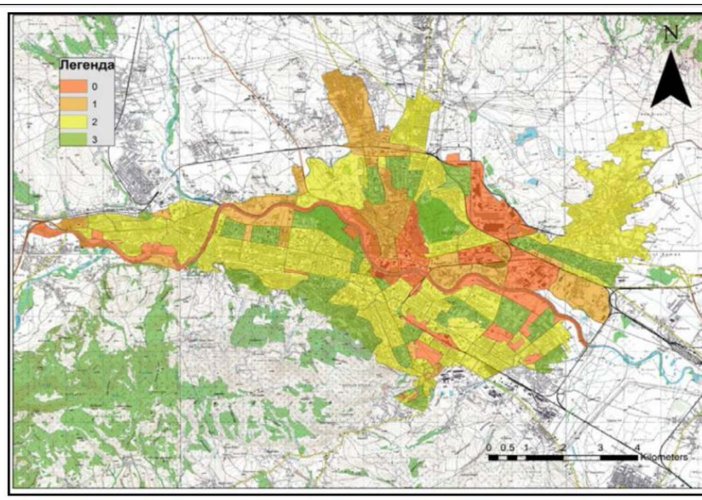
Public Green Spaces in City of Skopje	Area ha
City Park	38.8
Park Zena Borec	0.9
Characteristic Landscape Gazi Baba	105.0
Zajcev Rid	5.0
Sport-recreation centers	Area ha
Lake Treska	18.6
Saray	24.0
Green space in the city surrounding area	Area ha
Park-Forest Vodno	4537

Analysis of residential green space in the Municipalities in the City of Skopje from 2017 year, show that summary green residential space in 248,5 ha, and Municipality Aerodrom has the most green residential area with 80,4 ha (Table 2).

Table 2. Residential green space in the Municipalities in the City Skopje (Source:Студија за зелени коридори на град Скопје, Град Скопје, 2017)

Residential green space in the Municipalities in the City of Skopje	
Municipality	Area ha
Municipality Centar	19.5
Municipality Karposh	61.0
Municipality Gorce Petrov	9.2
Municipality Kisela Voda	20.8
Municipality Aerodrom	80.4
Municipality Gazi Baba	18.6
Municipality Cair	29.7
Municipality Butel	7.4
Municipality Suto Orizari	1.6
Summary	**248.5**

Assessment of the condition of urban green space in Skopje

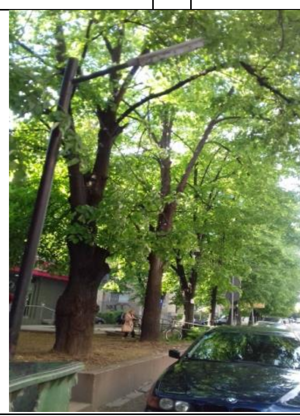


Assessment of the condition of urban green space in the City of Skopje
Geographic map of the urban area in City of Skopje
0-very weak condition of green space, 1-weak condition of green space, 2- medium condition of green space
4- good condition of green space, (Source: Студија за зелени коридори на град Скопје, Град Скопје, 2017)

Sustainable Green Development of public green spaces in the City of Skopje

Bul. Jane Sandanski, Skopje, Source Author

Street. Maksim Gorki, center of Skopje, Source Author



Developed Green Zones in the Urban Streets in Skopje, Source Author

Specific organization and development of the greening strategies of the City of Skopje can be analyzed by creating green infrastructure of the roads and central and side medians that perform a functional and an aesthetic purpose and provide some character of the street. Greening the road infrastructure in the City of Skopje will address several positive aspects:

a) physically separate traffic moving in opposing directions;
b) prevent uncontrolled, unpredictable, and unsafe traffic movements;
c) create a safe landing for pedestrians one-half of the way across a major street;
d) provide a planting area for landscaping and streetlights;
e) provide an excellent opportunity for the integration of stormwater treatment;

Greening strategies of the City of Skopje
Green Infrastructure of roads – central and side green medians as sources for greening the boulevard infrastructure in Skopje

Preserving historic landscape green spaces in the City of Skopje are important aspect in creating authentic urban character of the city by defining the urban structure, providing the identity of urban green areas, contributing to the aesthetic, historical and cultural identity of the city and defining the green infrastructure of the city.

Figure 7. Historic green spaces in the Skopje Fortress, Macedonia

5 SUSTAINABLE URBAN GREEN DEVELOPMENT IN THE CITIES

The expected outcome results in this scientific paper is creating urban climate mitigation and adaptation planning that will focus on the complexity of the cities with special emphasis of the City of Skopje. Targets for urban mitigation of carbon dioxide emissions are now urgent and imply reconfiguration of urban energy systems, transport, built environment and protecting and safeguarding biodiversity. Urban adaptation of cities requires integrated thinking that encompasses a whole range of urban functions. Sustainable city can be defined as a city that is significantly decoupled from resource exploitation and ecological impacts and is economically and ecologically sustainable in the long term.

The methodology approach in this scientific paper focuses on defining the measures for risk management and vulnerability of the urban climate, overcoming urban adaptive capacity aspects and creating urban climate adaptation planning and greening strategies that will be factor for sustainable development in the City of Skopje. The expected outcome results in this scientific paper is creating urban climate mitigation and adaptation planning that will focus on the complexity of the cities.

Urban green spaces are the crucial elements of every city. They affect the appearance of the city, provide diversity and shape the structural and the functional elements that cities. The concept for sustainable urban development and creating a city with high quality of life, City of Skopje should emphasize the concepts of keeping the existing public green

This Scientific paper will contribute to the wealth of information already available on climate change by going beyond context specific urban case studies that can help urban centers become better prepared and more resilient to respond changes in climate. It provides an overview of the current state of knowledge and practice, but also at existing gaps in our knowledge and new directions for work in this area.

The strategic approach to sustainable development according to the Macedonian scenarios include strategies that reduce the urban heat island effect, improve air quality, increase resource efficiency in the built environment and energy systems, as well as land use, urban forestry and biodiversity that to contribute to greenhouse gas emissions reduction while improving a city's resilience. The selection of specific adaptation and mitigation measures should be made in the context of other sustainable development goals by taking current resources and technical means and social needs of the citizens of the city of Skopje.

REFERENCES

1. Urban Areas and Climate Change: Review of Current Issues and Trends, Institute for the Study of Society and Environment, Patricia Romero Lankao Ph.D., 2008, pp.7
2. Urban Heat Island Mitigation Strategies, Institut National Quebec, Publication N1513, 2009, pp. 110-112
3. Macedonia- Environmental and Climate Change Policy Brief Final draft, 2009-05-04, pp.15-16
4. Студија за воспоставување на зелени коридори, Град Скопје 2017
5. Студија за озеленување и пошумување на подрачјето на град Скопје, Град Скопје, 2015
6. Macedonia's First National Communication under the United Nations Framework Convention on Climate Change, Ministry of Environment and Physical Planning
7. Indicators for Sustainable Cities, European Commission, 2015
8. Akbari, H., Konopacki, S. (2004) Energy effects of heat-island reduction strategies inToronto, Canada, *Energy*, Vol. 29, No. 2, pp. 191-210.
9. Brown, R.D., Gillespie, T.J. (1995) *Microclimate landscape design: creating thermal comfort and energy efficiency*. John Wiley and Sons, Chichester, 192 p.
10. Dimoudi, A., Nikolopoulou, M. (2003) Vegetation in the urban environment: micro climatic analysis and benefits, *Energy and Buildings*, Vol. 35, No. 1, pp. 69-76.
11. Gill, S.E., Handley, J.F., Ennos, A.R., Pauleit, S. (2007) Adapting cities for climate change: the role of the green infrastructure, Built Environment, Vol. 33, pp. 115-133
12. Johnston, J., Newton, J. (2004) Building green: a guide to using plants on roofs, walls and pavements. Ecology Unit, London, 95 p.
13. Adaptation to Climate Change-Policy instruments for adaptation to climate change in big European cities and metropolitan areas Ecologic Institute, Berlin/Vienna together with AEA group, ICLEI - Local Governments for Sustainability, European Secretariat and the Regional Environmental Center for Central and Eastern Europe (REC), 2007, pp.105-106
14. Urban Adaptation to Climate Change in Europe 2016, European Environment Agency, Denmark, pp.30-31
15. Climate Change Mitigation in Buildings, Transport and Energy Supply Sectors, First Biennial Update Report on Climate Change, Research Center for Energy and Sustainable Development, Macedonian Academy of Sciences and Arts, 2014, pp.50-51

DECENTRALIZATION AND THE NEW SETTLEMENTS IN SUBURBAN AREAS OF SKOPJE

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Abstract. *By using intelligent methods of urban transformation and decentralization of the Macedonian capital, we will try to improve the life of its citizens as one of the major goals of this paper. This study will examine and analyze the northern part of the city, encircling the region of village of Bardovci. This village is consisting with old and new parts which are not communicating to each other. Therefore, our mission through this paper is to propose a new urban project, previously prepared by serious urban analyzes, defining historical and heritage values of the existing structures. In the other hand, the project will attempt to join the both (old and new) current settlements and it will try to eliminate all the negative issues of the existing situation. The new project will also introduce the radical increasing of the quality of overall structure not only by creating new public facilities, new parks and green zones, new houses with independent courtyards, but also by creating new public transport connections with the rest of Skopje. Finally, our mission of transformation and decentralization could be implemented only if we are ready to change our existing mental settings in order to improve our lives in general.*

Keywords: *decentralization, transformation, urban, settlements, public, citizens.*

1 INTRODUCTION AND BASIC CHARACTERISTICS OF THE LOCATION

Good architecture ensures good interaction between public space and public life. But while architects and urban planners have been dealing with space, the other side of the coin – life – has often been forgotten. Perhaps this is because it is considerably easier to work with and communicate about form and space, while life is ephemeral and therefore difficult to describe.

This paper is a part of a bigger research considering the creation of urban plans in the existing urban areas in Skopje and around the Macedonian capital (Fig. 1)

1. Remodeling the existing urban area -“Novo Maalo” in the center of Skopje

2. Remodeling the existing suburban settlements in order to make it more independent as much as it could be - Village of Bardovci, Zlokukjani and surrounding housing- dwelling area.

3. Remodeling the existing rural settlements-Villages of Dolno Sonje and Gorno Sonje.

Why we have been chosen these areas?

The answer is: because Novo Maalo, Bardovci and Sonje have enough free space inside and around their existing boundaries which give us possibility to make interventions and to fill all the unused and uninhabited empty spaces with new public contents, new infrastructures and new building plots for new housing areas with individual private gardens and new organized public and green zones. (Fig. 2)

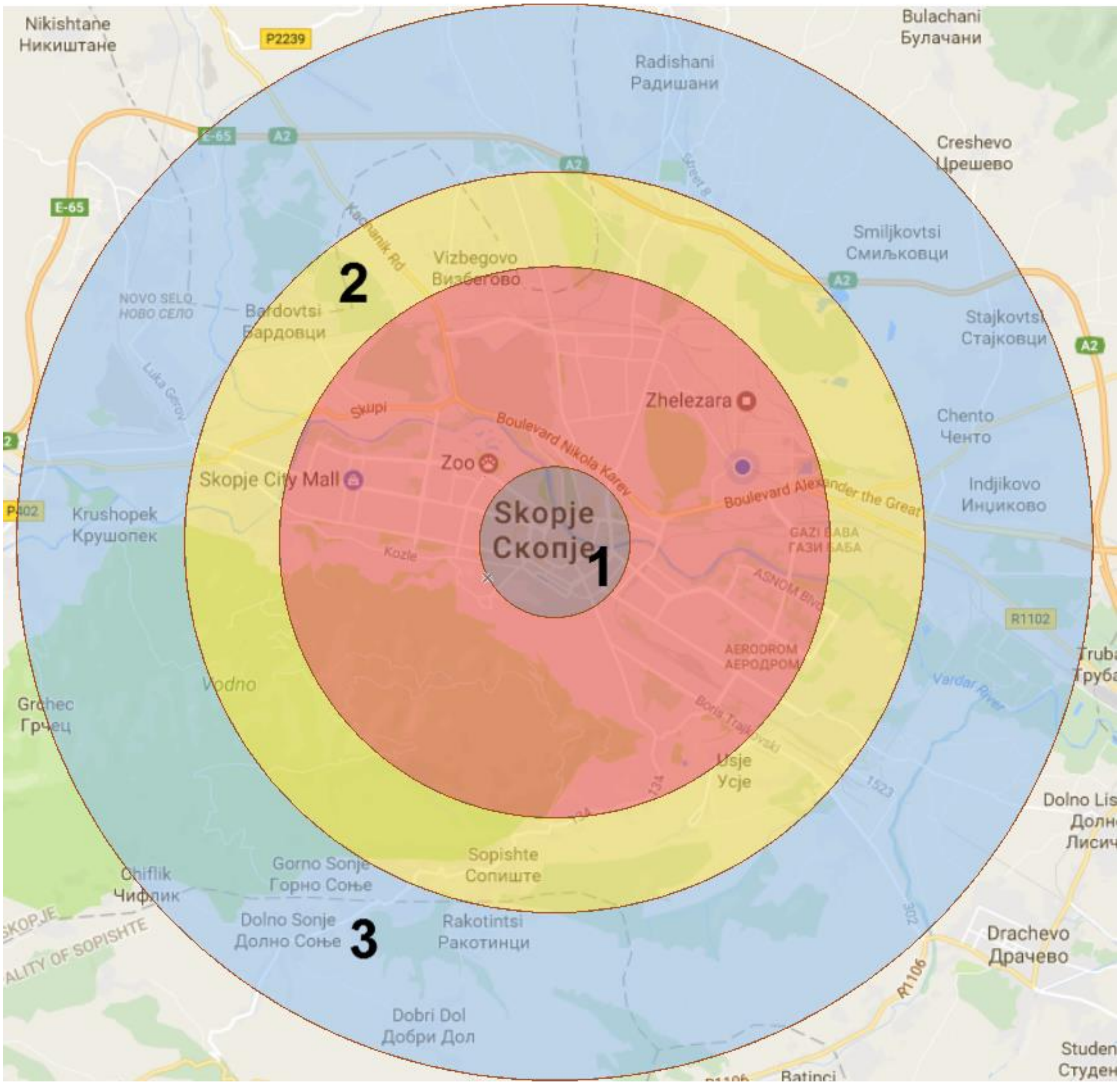

Figure 1. Locations of possible urban remodeling in Skopje

Considering the suburban areas, this study will examine and analyze the northern part of the city, encircling the region of village of Bardovci. This village is consisting with old and new parts which are not communicating to each other. Therefore, our mission through this paper is to propose a new urban project, previously prepared by serious urban analyzes, defining historical and heritage values of the existing structures. In the other hand, the project will attempt to join the both (old and new) current settlements and it will try to eliminate all the negative issues of the existing situation.

Figure 2. Photographs of possible locations for urban remodeling in Skopje

Village of Bardovci has become formally a part of a capital of Macedonia since the sudden enlargement of the city after the catastrophic earthquake in the 1963 year. Due to its favorable geomorphologic and climatic position of the settlement, and its closeness to the center of Skopje, this village represents a constant magnet for new inhabitants coming from other part of Skopje seeking for less polluted areas and calm living conditions. This tendency becomes popular especially in the nineties when the new embassy representatives and employees in the foreign missions in Macedonia were looking for a vacant residential area. This new residential district is situated as an extension to existing village of Bardovci but without any interconnections with the village in order to use the very few existing common public services. (Fig. 2, 3 and 4) Also, this new built area was created without serious urban plans for its development, without ideas for any new public facilities like: schools, stores, cultural contents. There is almost no public transport to connect the new settlement with the city as well. The first goal of this paper is to increase and stimulate the positive parameters (closeness to the center, favorable climate, high quality houses) of the existing settlements (old and new). The second objective is to eliminate all the negative segments of current structure in Bardovci and its surroundings (isolation, absence of public contents and public centers, very low quality and not frequent public transport, absence of planned urban growth) in order to establish a village that will exist independently implementing all the necessary public services, high quality and fast public transport.

Figure 3. Nowadays appearance of Southern Bardovci

Figure 4. Top view fragment of Northern Bardovci

2 THE PROJECT

LOCATION:

One of the most important things before the commencement of the project is to define the limits of the project. From the north, the boundary of the urban project is the current ring road and from the west there are natural limit of the location-the river Lepenec. The eastern side is limited with the existing service zone besides the “Kacanacki Pat” road and finally from the south, the location border is presented by the village of Zlokukani, current service zone along

"Skupi" street. Although the area under the current railway is less treated, the general guidelines will be given for its future development at the end of this study.

In urbanism and architecture in general, those borders, limits or boundaries does not have to be understood literary that everything ends with those limits. On the contrary, we must think about "How we are going to connect with all the surrounding areas around the future location of the project?" Therefore, our final goal is to introduce new quality for all new users of the future designed space, but even more important is to improve the quality of urban space of the existing surrounding areas and to increase the real estate value of overall territory (new + existing). The crucial element of the integration of new proposed design in the existing context is the creation of new public centers that will join the new and old. Second point is creating attractive views toward the new build area and toward the current structures from as much as possible standpoints. Next thing is to provide an "empty" unbuild but organized and landscaped public space offering a gathering space, a space for socializing and place dedicated for spontaneous meetings of people, and making save public corners for kids.

In the past thirty years this location has always been planned fragmentally and not as an integral part with the surroundings areas. The Detailed Urban Plans (DUPs) are never been treated the space in a bigger range, and they do not cover the whole structure. General Urban Plan (GUPs) is only giving the directions for the use of land, the height of the future buildings; the density of built space etc, but it doesn't give a detailed design. The new types of "urban plans for city quarters" are not treating the suburban areas and the location of Bardovci. Therefore, one of the main goals of this study is to create a pattern of a New type of urban plans that will enable much more efficiency and bring much more life quality for the rest of the "unfinished" or untreated urban zones of Skopje and its surroundings.

IDEA:

The general idea of the project is to create two new extension settlements of current Bardovci: Upper and Lower Bardovci in the northern and eastern side of the surrounding area of the existing village. These two settlements are planned to be joined with a wide range of public contents, new green areas, new infrastructure, which will represent the crucial connection with the existing and the new planned urban area. (Fig. 5)

The main objectives of this project are:

- to create an urban plan that will define the limits of the ORGANISED future growth of Bardovci,
- designing new settlements with low-rise houses with independent courtyards,
- creating bigger free and green area around the new houses comparing to the existing Bardovci;
- introducing a full package of new public contents integrated in every part of the new settlements;
- connecting the new settlements with the rest of the town with new streets and boulevards;
- introducing new public transport – the city train and two new train stations;
- protecting the existing sites with architectural and historic values (Skupi ancient settlement and the remains of Havzi Pasha Konak)

Elements of the project:

- Dwelling zone;
- Public zone;
- Inner road infrastructure;
- Water canals;
- Green zones;
- New public transport and new stations;

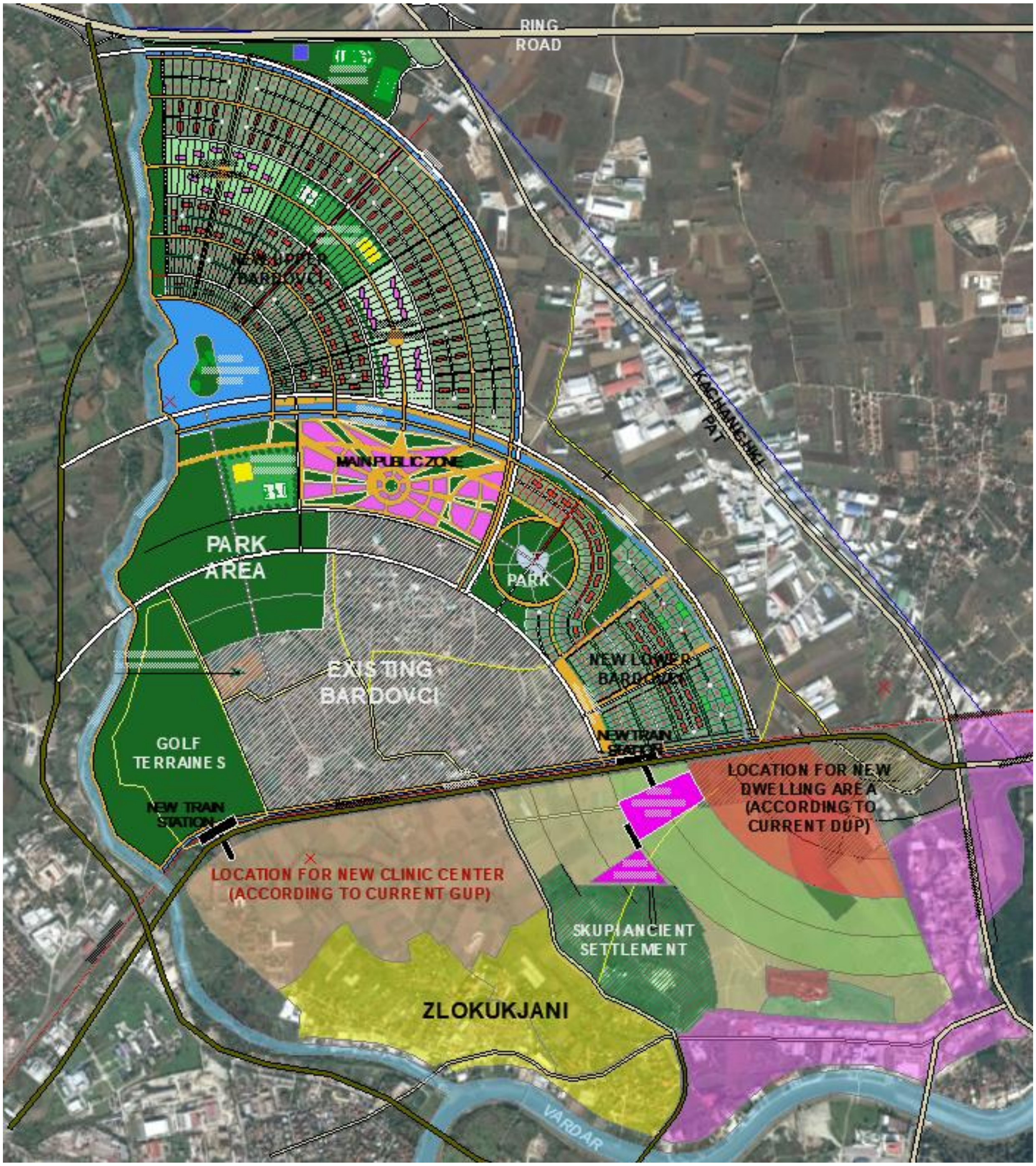

Figure 5. New proposed urban project of Bardovci and its surroundings

Dwelling zone

The basic element of this urban project is the dwelling unit represented with low-rise detached houses and multilevel row houses. The disposition of these two types of buildings is one of the most important parameters in the overall plan. There are several parameters that were taken in consideration in the creation of the dwelling zone.

- Views from and towards each dwelling unit
- Generous size of the courtyard of each individual house and of each multilevel row house.

- The minimum distance between the multilevel buildings situated one in front the other is planned to be 40 meters, and minimum distance between the low-rise houses situated one in front the other is planned to be 30 meters.
- The minimum distance between the multilevel buildings situated one next to each other is planned to be 18 meters, and minimum distance between the low-rise houses situated one next to each other is planned to be 12 meters.
- Minimum distance from the dwelling unit and the nearest public services is planned to be 300 meters.
- Parking for the inhabitants of the residence of the low-rise houses is conceived within their building plots, and parking for multilevel buildings is planned in the underground area within its plot.
- Possibility of pedestrian connections from the dwelling units towards the public services for every citizen of the new settlements.
- Possibilities of using water sports especially for those buildings that have water front (canals or artificial lake).

The current number of inhabitants of Bardovci is 1472.

New Upper Bardovci is planning to house 1924 inhabitants. (Fig. 6)

New Lower Bardovci will accommodate 1048 inhabitants. (Fig. 7)

Total number of new inhabitants will be 2972, plus the currents 1471 = 4 444 inhabitants (existing + new planned)

There are two types of buildings planned in this project:

- Housing Area consisted with low-rise houses (Building plan surface: 10/15 m per unit and 1500-2500 m2 for building plot including the building ground floor surface). The height of the houses is planned to be ground floor and first floor.
- Multilevel row houses (ground floor + two levels). One unit (42/10 m) has four houses.

Figure 6. New proposed urban project of Upper part of Bardovci

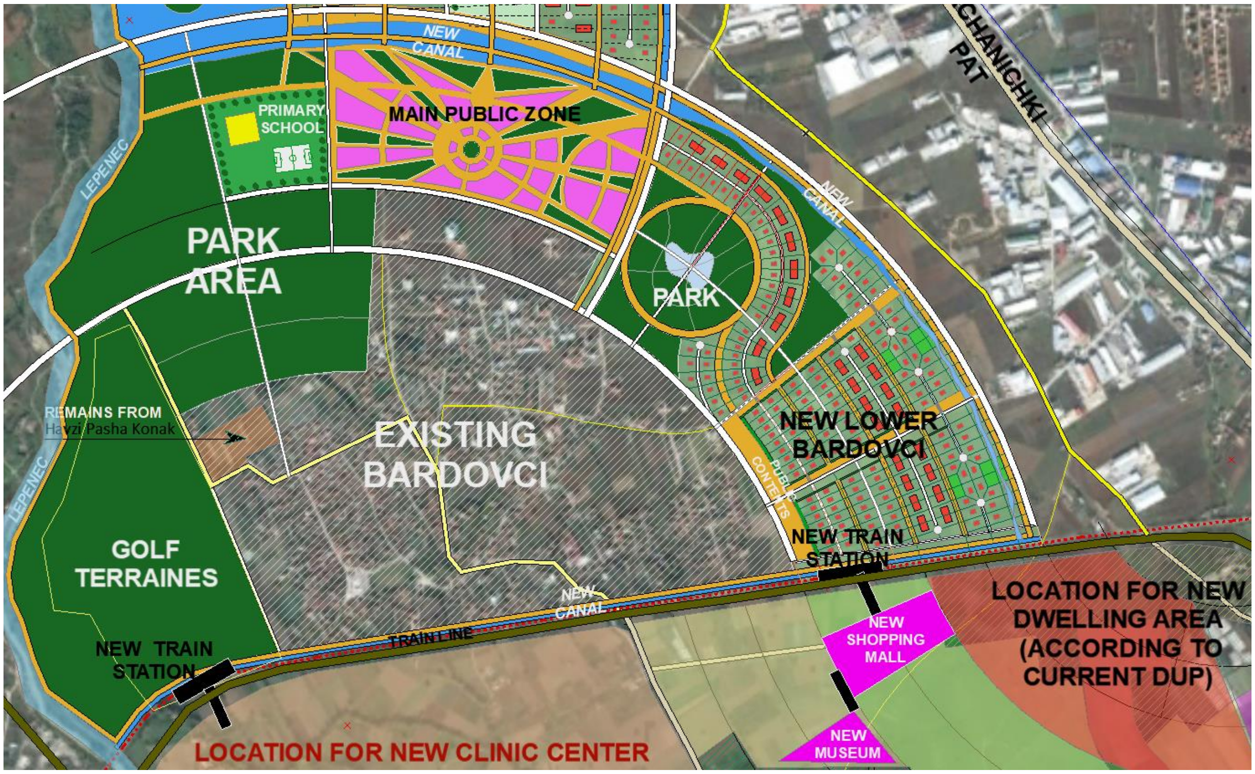

Figure 7. New proposed urban project of Lower part of Bardovci and its surroundings

Public Zone:

Public zone in this project is spread in several locations of the surrounding areas of existing village. It is integrated in the dwelling areas as public centers with lower hierarchical level (first or second degree public centers) or it could be represented as a separated public zone of third degree public center gathering the new and existing part of the village and lower and upper Bardovci from this project as well.

The Main Public zone is situated in the middle of the location of the project gathering the two new settlements and the current village.

The main Public zone has complex of low-rise buildings including:

- Shops (grocery, pet-store, flower market)
- Restaurants
- Café bars
- Banks
- Post office
- Police
- Primary School
- Sport Facilities
- Supermarket
- Cinema

Besides its basic role to connect old and new, gathering both parts of the new project as well, this Main Public center has a significant functions providing: social inclusion - making all groups of people within a settlement feel valued and important; enabling secure open public space for everyone; creating unique identity of the Bardovci that will make people proud and happy being part of this settlement; and making a healthy public space that will ensure clean air, abundance of sun, to be naturally ventilated, and to enable serenity of spirit.

The other, northern public zone is represented with Sport center in the farthest northern side of the location. It includes:

- Outdoor and indoor swimming pools
- Football terrain
- Tennis courts
- Basketball fields
- Running track all over the sport's center

This public center of fifth degree could serve not only for the residents of Bardovci, but also for the rest of the citizens of Skopje. This recreational public spot will play a significant role in a public life of Macedonian capital in general. Of course, local residents will have priorities (they will have much lower price for using its facilities) not only because the center is part of their settlement, but also to encourage other parts of the city to promote their own local sport's centers in order to establish a balance in every part of the city and to enable sport to be for everyone and to be close to everyone. Other reasons for these advantages for the local citizens having lower costs of using the sport center are in order to strengthen the social life in Bardovci and also to avoid possible safety issues coming from its outside users.

There are planned two public centers in the middle part of the Upper Bardovci including a new primary school. Lower Bardovci has two smaller public contents because of the proximity of new planned Shopping mall (planned with this study) in the near southern area of existing Bardovci and because of the proximity of an existing primary school in the current village.

In these public contents zone there are planned:

- Smaller food markets
- Bakery
- Barber Shop
- Small Libraries
- Kid's entertainment

Inner road infrastructure:

The local roads for vehicles are designed in order to reach easily each residence of the settlement, providing efficient communication between the housing, the exits of Bardovci and the surrounding boulevards that connects the rest of the city.

In general, the traffic network of the plan is consisted with separate tracks, separate drive ways for its every user. Inner infrastructure is conceived to serve its pedestrians, its car drivers, its bike riders and therefore this separation of paths in different locations allowing different type of traffic flow to function, will just increase the quality of inner infrastructure.

There are planned separate bike lanes, pedestrian paths and car roads through the new settlements.

Most of the local car roads are finishing with "dead ends" which enables creating a calm dwelling neighborhoods and more privacy to its users.

We are planning to use the current infrastructure of Bardovci village with the new proposed settlements in order to connect the existing houses with the new public contents which will serve also the current settlements.

Water canals:

The general idea of making new canals is using the water from Lepenec to create new alternative connection through the new settlements, introducing water sports like kayaking and increasing the landscape design and total image of the overall project. Also, the new canal serves as new natural boundary between the planned urban area and the surrounding existing zones.

Green Zones:

The green zones are one of the biggest trumps of the future project.

If we are avoiding the city traffic, city pollution, and we are in seek for nature, we cannot avoid planning a huge area dedicated for greenery and park zones.

First of all, each house has its own courtyard which makes part of overall greenery.

Second, green zone is also making part of public open spaces which are combined with parks.

Western part of the location, along the river Lepenec, is planned to be a green zone, attractive for different recreation sports activities like: biking, jogging etc. Also, between Existing Bardovci and river Lepenec, there are planned a park area with golf terrains with the size of its territory as the current village (around 90 hectares).

Other bigger green zone we can find as a part of the Lower Bardovci is the junction area situated between the Main Public Zone and the Dwelling area.

The last green area is conceived as a part of a Sport Center situated in the northern limits of the location, near the existing Ring Road.

New Public Transport and New Stations:

The role of public transport in a city has a crucial significance in a city in general. Its quality, its degree of network development, its frequency, its proximity to the citizen's destinations and their homes, its comfort, its safety, its prices, … The new City Train should connect the new settlements and the rest of the city. (Fig. 8)

The possible stations:

- Volkovo
- Bardovci1 and 2
- Vizbegovo
- Butel1 and 2
- Zelezara
- Jane Sandanski Sport Center
- Skopje Fair
- Transport Center
- Kisela Voda 1 and 2
- 11 Octomvri District
- Lisice
- Dracevo

Figure 8. New proposed public transport network in Skopje

The new stations in our project are Bardovci 1, at the New Clinic Center and Bardovci 2 (east of the location) at the New Planned Shopping Mall (west of the location).

3 THE SOUTHERN SURROUNDING AREA

We have ONLY general guidelines for the future development of the southern surrounding area (between the railway line and "Skupi" street). (Fig. 9)

This empty area has some plan in the GUP and DUP, and some of them are compatible with our proposed project. We are respecting in the overall urban design the position of the future new Clinic Center and we are planning to integrate it with our project. On the right site there are one current DUP (dwelling zone with very few public contents) which is also compatible with our project, regardless its different shape comparing to ours. However, we are proposing here a big Shopping Mall, a New Museum right next to the Skupi archeological and touristic "must see" destination for every new visitor of Skopje. Then, probably the most important thing which is equally important to a new project, are the New transport (City Train) stations, one at the Clinic Center Location, and the other between the southeast of the new project and the New Shopping mall.

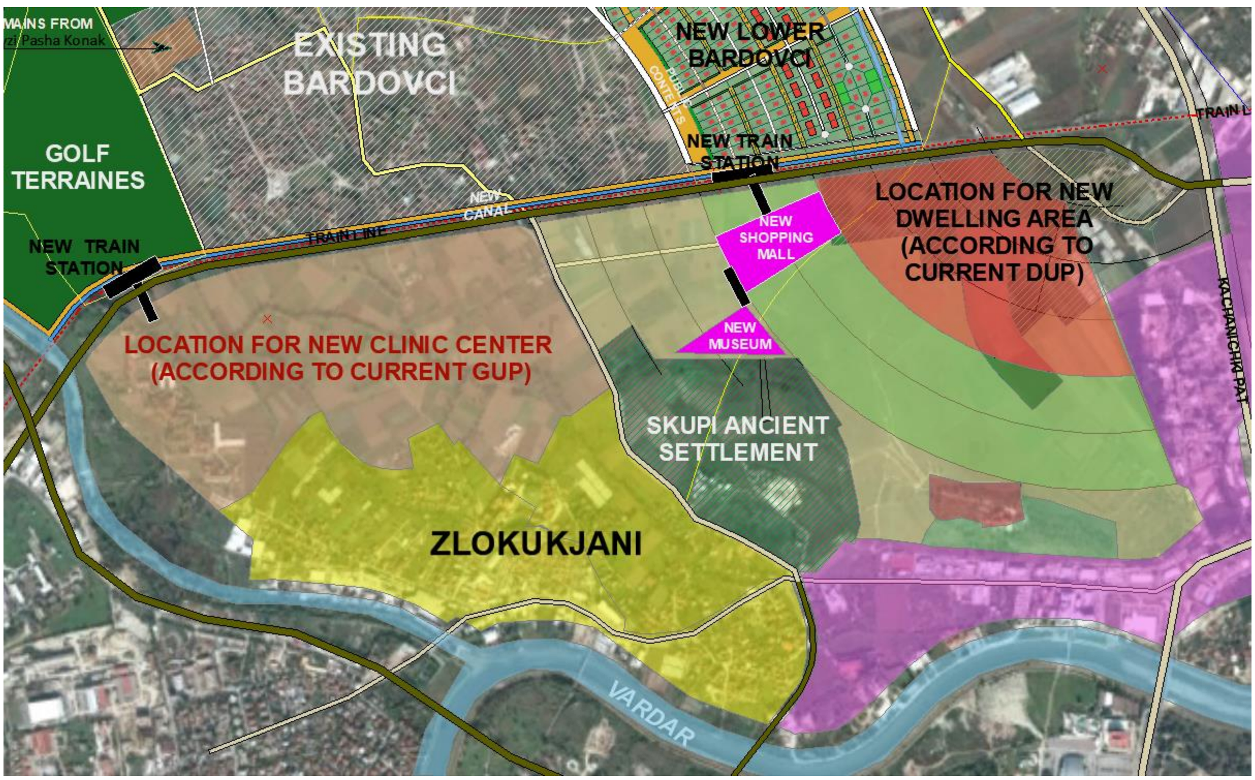

Figure 9. The Southern surrounding area of the proposed urban project and its development

4 CONCLUSION

As we said in the beginning of the presentation, this project is inspired as a part of a bigger research which includes urban interventions in urban, suburban and rural and not populated areas.

Choosing the village of Bardovci we have tried to create a project that will fortify all the week points in the sense of proposing different public facilities and organized open spaces. Finally, we are trying to stop the spontaneous growth of this attractive part of the city proposing a clear vision of how this settlement should be developed in the future.

Because, the current unplanned growth means, no public zones, absence of infrastructure, isolation from the rest of the city….

With this project, we strongly believe that this concept of planning bigger areas than DUPs, thinking as well of the connection with its surroundings in every way (transport, joining public and green zones).

The final plan should be: The achievement of complete independence from the city in one hand (regarding the public contents and the new public center) and much better integration and connection with the rest of the city in the other hand (using the Ring road, The extension of Boulevard Ilinden, the extension of Slovenia Boulevard, The new proposed City Train and the two New Train station in western and eastern part of the location of the project).

REFERENCES

1. Lawrence, A. Herzog. Return to the center: culture, public space, and city building in a global era, University of Texas Press, Austin, 2006
2. Bruce Mau. An Incomplete Manifesto for Growth - Lessons for Architecture, University "Ss. Cyril and Methodius" –Faculty of Architecture, Macedonia, 2001.
3. Piers MacNaughton , Usha Satish , Jose Guillermo Cedeno Laurent , Skye Flanigan , Jose Vallarino , Brent Coull , John D. Spengler a , Joseph G. Allen The impact of working in a green certified building on cognitive function and health, Building and Environment, Vol. 114, 2017.
4. Anne Steinemann , Pawel Wargocki, Behzad Rismanchi, Building and Environment, Vol. 112, 2017.
5. Renata Paola Dameri, Camille Rosenthal-Sabroux. Smart City How to Create Public and Economic Value with High Technology in Urban Space, Springer International Publishing Switzerland, 2014.
6. Stanley Buder. Visionariess and Planners - The Garden City Movement and the Modern Community, Oxford University Press, New York, 1990.
7. Danica Mitkovska, Live births, deaths and migration by urban and rural areas, by regions, 2015, State Statistical Office of Republic of Macedonia, Skopje, No: 2.1.16.26, 2016.
8. Howard Ebenezer. Garden Cities of Tomorrow, Swan Sonnenschein & CO. , Ltd Paternoster Square, London ,1902.
9. Lewis Mumford. The Culture of Cities, Harvest/HBJ Book Harcourt Brace Jovanovich, Orlando-Florida, 1970.
10. Andrew L. Dannenberg, Howard Frumkin, and Richard J. Jackson, Making healthy places : designing and building for health, well-being, and sustainability, ISLAND PRESS, Washington, DC, 2011.
11. Eran Sher. Handbook of Air Pollution from Internal Combustion Engines Pollutant Formation and Control, Academic Press, San Diego,1998.
12. Konstadinos G. Goulias, Transportation systems planning : methods and applications, CRC Press LLC , Boca Raton, 2003.
13. White, Peter, Public transport : its planning, management and operation, Routledge, Abingdon, Oxon, 2009.

SOIL INVESTIGATION ON THE BOTTOM OF OHRID LAKE BY CPT-U TEST

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Abstract. *In 2008, the activities for construction of museum complex started on wider scale at the archeological site on the peninsula Gradishte Ohrid Lake, by patronage of the Board for cultural heritage of the Republic of North Macedonia. The works are to create an authentic reconstruction of prehistoric palafitte settlement on timber piles, located in the place called "Bay of the bones", which dates from the late bronze age and beginning of iron age, in the period of 1500 – 700 BC. The aim of such activities was to build a museum on water that would be unique to the Balkans by its form, construction and cultural heritage. In the first phase, an offshore investigation with CPTu tests was conducted for the means of this construction, for definition of the geotechnical characteristics of the soil in the bottom of the lake, as well as defining of the depth on the base rock material. In accordance with the results from the geotechnical investigations, the timber piles construction is designed and executed, on the same place in the lake where prehistoric artifacts were found. In this paper the geotechnical investigations, technical characteristics and details of the authentic reconstruction of the timber pile construction are detailed.*

1 INTRODUCTION

The Ohrid Lake was formed by tectonic forces, 2-4 million years ago, therefore it is considered to be the oldest lake in Europe and one of the oldest in the world, along with the Baikal Lake in Kafkaesque and the African Lake Tanganyika. In Ohrid Lake more than 146 endemic species and fauna are found, mostly because of its age, and the fact that it is surrounded by hills and mountains. As a result, in 1980, UNESCO proclaimed it as site of cultural and natural values of the global patrimony. Still, this natural system does not only abound in endemic species and fauna, but also at the bottom of the lake exceptional archaeological values from the old prehistoric period, such as pile settlements, have been preserved.

Pile settlements, as a way of living for people in the past, were especially characteristic of the period of Prehistory, in the Neolithic, Eolithic, Bronze and Iron Age. They were built and used, generally, for the protection of the prehistoric man from the attacks by wild animals as well as by other tribes. This also allowed them to obtain food either by water or by land. These pile settlements, in Europe can be mostly found in Switzerland, Northern Italy, Germany, Austria etc., originating from various chronological periods. Pile settlements in Macedonia were first mentioned by the antique Greek historian Herodotus (B, 16) who described the Prasiade Lake, nowadays known as the Dojran Lake. Apart from the remains of prehistoric pile settlements found on the territory of the Dojran Lake after the archaeological research conducted in the last years of the 20th century, such remains have also been found on the territory of the Prespa Lake and Ohrid Lake in North Macedonia.

The only settlement of this kind which has been reconstructed, and which can be found on the coast of the Ohrid Lake, in the Bay of the Bones, will be the topic of this research.

2 GENERAL CHARACTERISTICS OF BAY OF BONES PILES SETTLEMENT

For the first time in Macedonia, in the years between 1997-2005 and 2007-2008, underwater archeological researches were carried out in the Ohrid Lake next to the Gradiste peninsula, more specifically in the Bay of the Bones. These detailed researches at the aforemetioned location, resulted in the discovery of a prehistoric pile dwelling settlement, where about 6000 remains of timber piles with a diameter of 13.0-30.0 cm, comprising a surface of 8500 m2, were registered. These piles, grouped in such a way, constituted the foundation of a joint wooden platform. According to the archaeological researches, it is assumed that 20 prehistoric residential facilities built from similar material had been located above this platform. Regarding the authentic construction execution, it is important to mention that these piles were registered at a depth of 3.0-5.0 m, while the nearest piles are found 12.0 m from the coast of the lake, which is oriented South from the Gradiste peninsula. The survey of the bottom of the lake registered ancient ceramic pots, stone artifacts, animal bones and many other objects used as tools.

Figure 1. Remains of wooden objects at bottom of Ohrid Lake

Figure 2. Remains of timber piles at bottom of Ohrid Lake

Based on the results obtained from these detailed researches, and in accordance with the archaelogical analysis of the objects taken out from the bottom of the Ohrid Lake, it can be said with absolute certainty that this pile settlement dates back to the late Bronze Age and the beginning of the Iron Age, that is the period between 1500 and 700 B.C. Due to these reasons, this object has raised considerable interest among the members of this professional field. As a result it was decided to start the construction of a museum on water, the only one of this kind on Balkans, under the auspices of the Macedonian Ministry of Cultural Heritage.

3 GEOTECHNICAL INVESTIGATIONS

The specific location of the pile settlement's construction in the waters of the Ohrid Lake imposed the need of uncommon geotechnical investigations. It was decided to conduct offshore soil investigations through the CPTu test, keeping in mind the difficulties in handling the standard drilling equipment in a limited space, as well as the inability to obtain an undisturbed soil sample from the bottom of the lake. Undoubtedly, as a result of these reasons, the CPT test has been an essential part of offshore soil investigations in the last 40 years.

The position and dimensions of the platform, generally required the conduction of the tests at 6 investigation points, all in 20-40 m distance from the shore of the Ohrid Lake. Taking into consideration its distance from the shore of the lake, the conduction of the offshore tests was adapted to shallow waters (<30 m), by placing the equipment on a floating barge with a central core in the middle. The tests were provided using an electric piezocone CPTu, type ENVI Memocone.

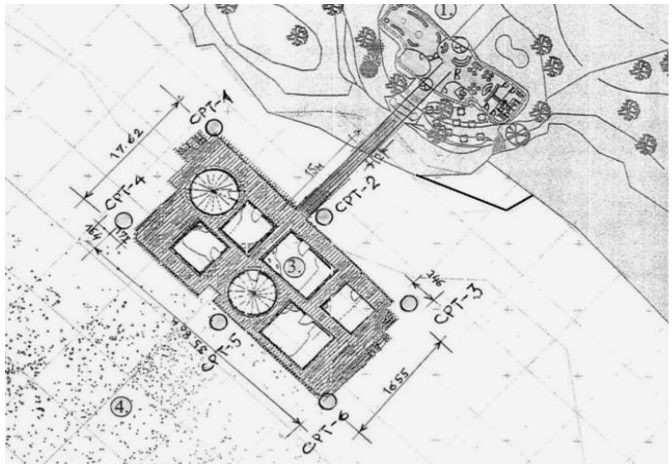

Figure 3. Layout with disposition of investigation points

Despite the fact that the tests were carried out in shallow waters, care was taken for the equipment to be well anchored to the bottom of the lake in order to prevent any horizontal displacements and inclination. In this way the free-standing casing protrudes trough an anchored barge, with the hydraulic jacking system mounted on a stable casing (Figure 4).

Figure 4. Offshore investigations with CPT-u

Because of the nature of the constructions itself, it was very important to determine the soil profile of the lake bottom, which is without doubt one of the biggest advantages of this type of in situ testing. The tests were carried out to varying depths, until the power of the penetrometer of 200 kN was reached which indicates the appearance of the base rock material, limestone. The base rock material is registered at a varying depth from the surface of the lake, and with an inclination of n ≅ 1:2.8, with E-W orientation i.e., from shore to the lake (Figure 5).

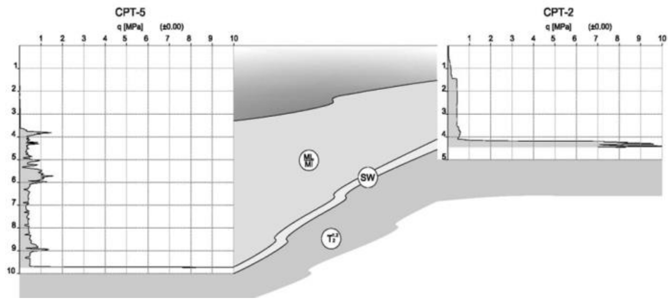

Figure 5. Offshore investigations with CPT-u

The identification of the soil materials will be done according to Robertson (1990) normalized charts, which offer a three-dimensional system for soil classification. The advantage of this popular method for classifying soil materials to others is that it uses all three series of data from the CPTu test (qt, fs, U2) which is essential for this kind of offshore investigations. The normalization of the CPTu data, will be done according to the equations (1) to (3) below (Wroth, 1988). Considering that the piezocone used in the tests, only measures the pore pressures behind the cone U2, the normalization of the sleeve friction fs to ft will not be done.

$$Q_t = \frac{q_t - \sigma_{vo}}{\sigma'_{vo}} \quad \text{normalized cone resistance} \qquad (1)$$

$$F_r = \frac{f_s}{q_t - \sigma_{vo}} \quad \text{normalized friction resistance} \qquad (2)$$

$$B_q = \frac{\Delta U}{q_t - \sigma_{vo}} \quad \text{pore pressure ratio} \qquad (3)$$

Analyzing the obtained data values from all 6 conducted tests, it can be concluded that the registered data values, according to all three parameters, indicate materials of a similar kind in a quasi - homogenous zone up until the registering of the base rock material. As a result, the series of values of a characteristic CPTu test will be shown and analyzed below (Figure 6).

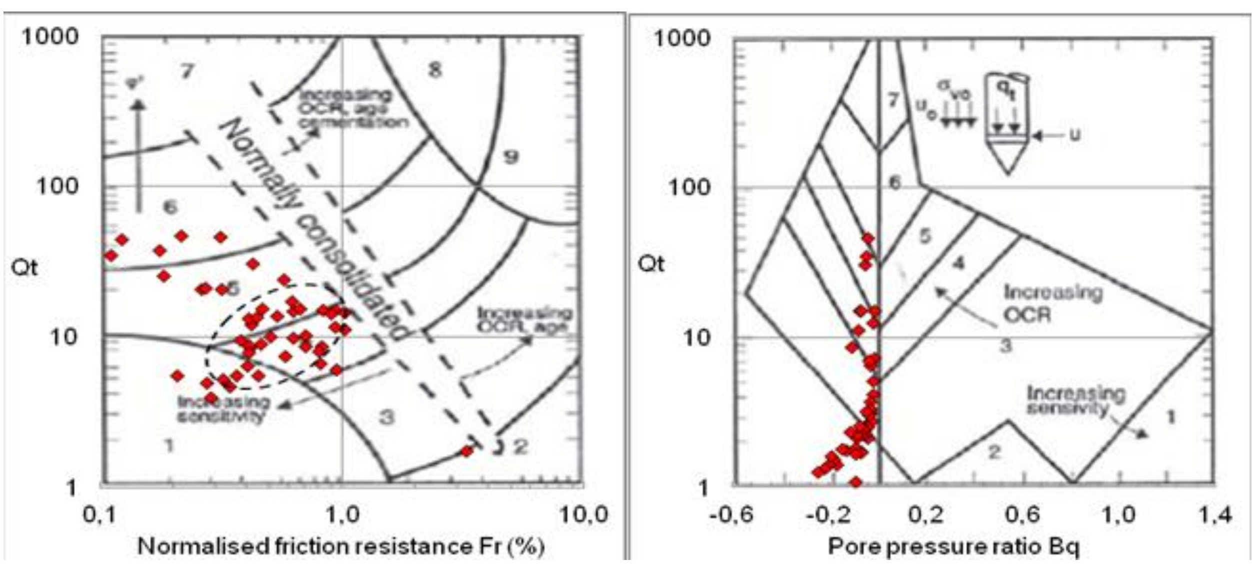

Figure 6. Charts of soils classification from CPTu test, by Robertson (1998)

According the diagrams, the series of values are generally concentrated around zones 1, 3 and 4, interpreted as sensitive fine-grained soils and silty-clay mixtures, which overlaps with the other examinations and analogue experiences, for this micro-locality. Smaller number of values refer to other zones in both diagrams, which is completely expected and pointed out by Robertson in his researches. Based on the conducted tests, a classification was done according to the consistent condition of the soil material, in accordance with Larsson and Mulabdic's method, based on piezocone tests of sensitive fine-grained soils. A preliminary conclusion can be made with this method about the bulk weight of the tested material, which in this case ranges between γ=12.7÷14.7 kN/m3 (Figure 7).

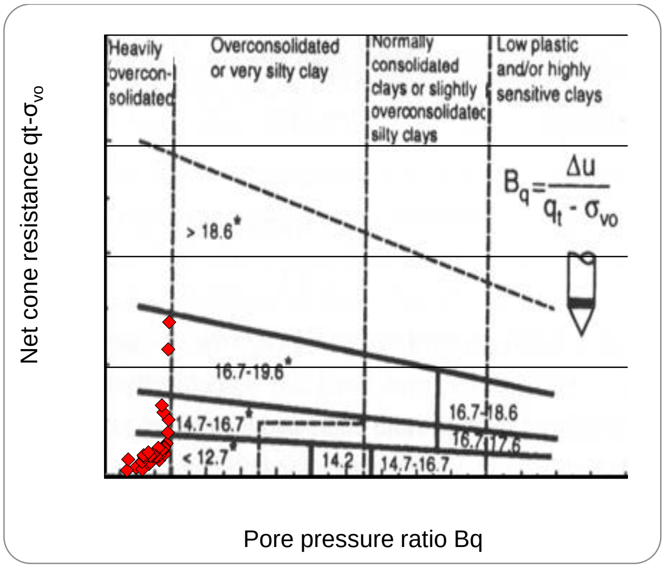

Figure 7. Chart of soil classification from CPTu test, by Larsson&Mulabdic

From the conducted tests and analyses, and with the purpose of choosing a suitable construction system, it can be said that the soil under the surface of the future platform on which the timber piles needed for the authentic reconstruction of the settlement are to be placed, has extremely weak geotechnical characteristics to a depth of 4.2-10 m.

4 AUTHENTIC RECONSTRUCTION OF THE TIMBER PILE SETTLEMENT

4.1 Materials for execution of the pile settlement

According to the requirements imposed by the Institute for Protection of Cultural Heritage, the complete reconstruction of the settlement was to be authentic. This entailed use of the equivalent materials used in its original construction. The underwater archaeological investigations determined the use of piles made of oak wood, with a diameter of 15-30 cm.

Considering the extreme atmospheric influences, constant influences of water, as well as the fluctuation of the water level during the period of exploitation of the piles and the above-water platform, it was necessary to subject these materials to impregnation. Thus, it was decided to use a method of impregnation of the wood, by a procedure including the use of vacuum and pressure in special closed devices – autoclaves. It is important to mention that particular care was taken in the choice of means for this process, in order for it not to contaminate the environment and not to be toxic for the wildlife in the surrounding where it takes place.

4.2 Execution and technical characteristics of the construction

In coordination with the Institute for Protection of Monuments of Culture, it was decided the platform of the pile settlement to be positioned near the site where the remains of timber piles and other archeological artifacts were found. The dimensions of the reconstructed platform, on which the museum is set, are 25 x 42 m and it is placed on 1012 timber piles. These are placed in 25 rows at an average axial distance of 1.0 m, with a diameter of 20 cm, in coordination with the main project for execution of the construction. According to the geotechnical investigations and the lithologic structure of the terrain, it was determined to drive the piles into the base rock material, as end bearing piles, in order to avoid the possibility of differential settlements of the platform. Possible flooding was taken into consideration in determining the length of the piles, besides the lithologic structure of the terrain. The piles are positioned 2.0 m above the surface of the lake in order to avoid flooding of the platform due to fluctuation of the water level or waves. Therefore, piles with length of 6.0-12.0 m were chosen, which were supposed to be driven into the base rock material and which were to penetrate it to a minimum depth of 0.5 m. The depth of penetration is depending on the conditions extent to which it had degraded in the upper parts. Piles placed in this way, with a varying depth, adapted to the field conditions, were hydraulically driven through the soil material with height of 1.2-5.7 m (Figure 8).

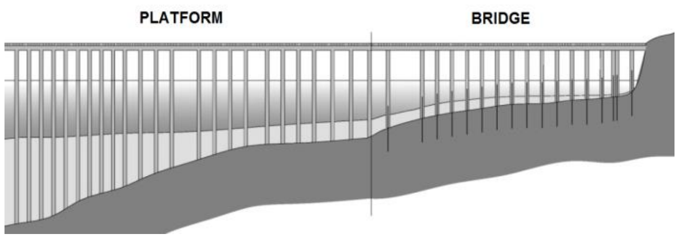

Figure 8. Cross section of the timber pile settlement

Additional type RTS vibratory equipment was used for overcoming the friction resistance on the surface of the piles, in the process of their driving through the soil material at the bottom of the lake. In the upper part these piles will be connected to wooden beams, also made of oak, in order to ensure greater rigidity of the entire construction system, in case of horizontal or vertical load.

The length and position of the bridge which provides a passage between the shore and the platform, was chosen based on the remains of piles nearest to the shore of the lake as well as on their schematic positioning, also determined with the underwater investigations. In accordance with this, the wooden bridge with a length of 19.0 m was anchored in the shore in order to prevent any horizontal movements of the platform. In the execution of the bridge, 68 piles were placed in 17 rows at a distance of 1.0 m.

Figure 9. Preview of the authentic reconstruction of timber pile settlement

The execution and the driving of the piles from the reconstructed pile settlement, took place in specific conditions, in the waters of the Ohrid Lake. For this purpose, a floating barge was brought and mounted by means of a special transport. The dimensions of the platform are 7.5 x 17.0 m, and its capacity allows for unobstructed functioning of the machinery with a weight of 25-30 t.

5 CONCLUSION

North Macedonia is great mine of cultural and historic inheritance; therefore, projects of this type should become common activities in government's projects for promoting tourism and cultural legacy. The Museum on water represents an authentic reconstruction of a settlement from the Iron and Bronze ages, and it is a tourist attraction for Macedonia but also for many visitors from abroad. All the materials used in this construction, as well as the means used in the process of testing and research are from natural material, in order to preserve the natural environment and not to harm the existing flora and fauna.

The role of geotechnical engineering in preservating this historical monument took major part in the whole project. The investigations as well as the planning, designing took essential part in the authentic reconstruciton of the whole project.

Just a few meters from the shore is the passage, not only for a simple settlement, but a passage for a real time travel experience of tourists from all over the world that will find themselves right in the prehistoric times.

REFERENCES

1. Baldi, G., Belotti R., Ghionna V.R., Jamiolkowski M., Lancellotta R., Robertson P. K, (1989) "*Shear strength of sand from CPT*", Proc. 12th ICSMFE, Rio de Janeiro, p.p. 165-170.
2. P. K. Robertson, J. J. M. Powell (1997). "*Cone Penetration Testing in geotechnical practice".*
3. M. Sachetto, A. Trevisan (2005). „*CPTs executed in dificult conditions using CPTWD and its future developements*"
4. P. K. Robertson, K. L. Cabal 5th edition (2012). „*Guide to cone penetration testing"*
5. P. Kuzman, E. Kochkovska, M. Sekulovski (2010). „*Museum on water, Bay of the Bones, reconstruction of pile dwelling settlement*"
6. R. Poulsen, B. N. Nielsen, L. Bo Ibsen (2011). „*Field cone penetration tests, with various penetration rates-Tests results*"
7. H. Gjorgjevski, S. Suvaka, B. Veljanovski, D. Nikolovski, A. Stojkovska (2009). „*Main Project for authentic reconstruction of palafitte settlement on timber piles „Bay of the Bones" (in Macedonian).*"
8. K. Bahchevandziev, Gj. Gruevski (2009). „*Methods of improving the quality and impregnation of oak tree exposed on extreme atmospheric influences, (in Macedonian)*"
9. Schanz T., Vermeer. P. A. (1996): "*Angles of friction and dilatancy of sand*", Geotechnique vol 46 (No.1), pp. 145-151
10. Terzaghi, K. (1967): "*Soil Mechanics in Engineering Practice",* John Wiley and Sons
11. Terzaghi, K. (1936): „*Theoretical Soil Mechanics*", John Wiley and Sons, Inc. New York

ALL-CERAMIC CROWNS IN THE FRONTAL REGION – STUDY CASE PRESENTATION (PINK & WHITE AESTHETICS WITH GINGIVECTOMY)

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Abstract. *The modern lifestyle brings the need for an ideal appearance and a beautiful smile. The correction of the physiognomy today is one of the basic goals of patients who are looking for the aesthetics of the face and teeth. In the frontal region the relation of the teeth to the surrounding soft tissues is very important. The harmony of pink and white aesthetics is a priority. Any deviation from the marginal gingival symmetry is counterproductive for the final result and has a negative effect on the aesthetics and proportions of the teeth. In addition to modern dental materials and equipment, it is very important to have a precise and thorough treatment plan at the start, but also a vision for a positive result. Technical skills, knowledge and manual dexterity and patience are needed, but most of all, to have an idea is of utmost importance.*

Keywords: *smile, aesthetics, marginal gingiva, physiognomy, teeth.*

1 INTRODUCTION

Contemporary living imposes the need for aesthetics restorations, especially of teeth in the frontal region. Nowadays we are not only talking only about nice teeth, but also about a stunning smile. There are millions of questions in our mind about how to get to a dazzling smile. Very often, we, the dental doctors, have a professional challenge to fulfill the needs and wishes of our patients for the perfect smile. There is much more than the beauty itself as a main field of interest of the aesthetic dentistry. It implies oral rehabilitation with maximum aesthetic that satisfies our patients. The smile not only affects the face and the body, but also the self – confidence of the human being. The affection of the aesthetic appeal in the everyday living is very important component. While reconstructing the frontal region we give great importance not only to the function, but also to the aesthetic parameters. These parameters are the focus of our interest - the teeth with the surrounding gum, the mucosa of the oral vestibulum and the lips. The gum represents the frame of the teeth and it is very important element in achieving final results when planning the prosthetic dental treatment. The gum covers the coronal parts of the alveolar ridge and it forms the interdental papillae which in their base have triangular shape, but their tip ends at the contact point of the tooth. It has to be always pink, firm, and not inflamed. Every exception of the gingival symmetry will affect the final result of the prosthetic rehabilitation in negative way. There are strictly defined steps for creating and configuring the smile from a dental point of view. We are led by generally accepted parameters - the proportion between the facial median line and the teeth, their symmetry, incisal length, axis, interdental contact points and surfaces, the shape, size and color of the teeth. In terms of soft tissue aesthetics, the bi-pupillary line, the smile line and the line of lip angles are important. Before the start of the treatment we need to notify all irregularities that should be addressed during the treatment phase. We need modern materials and techniques, precise treatment plan and vision of the final result. Apart from the equipment, knowledge and technical skills, to have an idea is of paramount importance.

2 MATERIAL AND METHODS

The patient's initial presentation revealed a disharmony between the teeth and the surrounding soft tissue (Fig.1) To solve this challenging problem, taking the turbine in hand right away and starting with tooth preparation is not a viable solution. Good tooth preparation technique and modern dental materials in the dental laboratory materials are not sufficient for a successful clinical outcome.5,6,7 It takes a creative engagement, teamwork and well-planned workflow to fulfill this goal. The first step was the complete clinical examination, which revealed the present irregularities and the possible solutions to them. The clinical decision to reconstruct the frontal region was based on extensive analysis that started with a patient interview, several anatomic impressions and production of studio models necessary in the further phases as a reminder of the starting position. Panoramic and intraoral x-ray images were also done in order to evaluate the condition of the teeth, especially the periodontal tissues; the length of the roots and their relation to the surrounding bone. We took photos of the patient's face (later used for drawing special prosthetic lines), occlusion photos and photos of the prosthetic rehabilitation workflow phases.

The second step was reaching out to the newest digital diagnostic methods - multiple measures and drawing several orientation lines on the face that connect the forehead, the eyebrows, the eyes, the lips and the chin. (Fig.2) The goal was to get ideal symmetry and aesthetic in the frontal region. The gum line was parallel to the bipupilar line and the base of the nose. Based on the zoomed photos of the teeth, we were able to create computer simulation. The procedure started with drawing two parallel lines in the intercanine sector. We proceeded with drawing the marginal edges of the gum. The next step is to elevate the level of the gum to the desired height on order to achieve a satisfactory height/width proportion of the future all-ceramic crowns. The purpose of this simulated gingivectomy was to obtain equal shape and size of the frontal teeth and harmonic dental arch in the cervical part of the teeth.8,9,10 Therefore, this digital workflow was very important step in achieving a satisfying smile (Figure 3). After the thorough discussion about the designed computer simulation among the team members and its final approval by the patient, we started with the clinical phase of the treatment. A terminal anesthesia was administered in the frontal region (Scandonest 2 %, Septodont, Saint-Maur-des-Fosses, France). After the measurements with 1mm graduated periodontal probe (UC-15, Hu-Friedy, Chicago, USA) that started at the incisal edge of the teeth, bleeding points in the soft tissue were created in order to mark the anticipated zeniths of the gingival margin in accordance with the digital design. The soft tissue was removed with paramarginal, intrasulcular incisions and final excision using 15 C blade (Swann-Morton, Sheffield, England). A full-thickness flap was gently raised at some sites in order to gain access for bone removal and osteoplasty with diamond burs in order to create favourable anatomical conditions for new biological width formation. The tissues were sutured with vertical mattress sutures using 5-0 polypropylene suture (Assut Medical, Pully, Lausanne, Swiss). Two week later the sutures were removed. (Fig.4) One month later we moved to teeth preparation phase under local anesthesia. During the preparation we paid attention to the parallelism between the teeth and the space between the antagonistic teeth. We ended this phase with tissue trimmer (porcelain turbine drill) to add final touch to the gum, the papillae and to open the gingival sulcuses (Fig.5 and 6). The patient's mouth was rinsed with antibacterial solution and alginate anatomical impression was taken for production of studio models in hard gypsum (Fig.7). When the gypsum model wa ready we started with wax-up modelling, with which we envisioned the future teeth with their shape, length, width and convexity (Fig. 8 and 9). On the waxed teeth we did another measurements . We can theoretically use many mathematical formulas, but the simplest is the one where we divide teeth's width with their length. The gained result should be a coefficient with values from 0.75 to 0.85 and it guarantees ideal shape of the waxed-up teeth. We applied this protocol, but we also used some personal creativeness in adding or removing wax to get a realistic image of the future all-ceramic crowns. (Fig.10)

3 RESULTS

Based on the digital wax-up design, PMMA provisionals were fabricated. They had multipurpose function: to serve as protective bandage for the fragile marginal gum, protection of the sensitive prepared teeth, restoring of function and aesthetics in the patient's everyday life, maintenance of the newly gained gingival levels and guidance for papillae formation for pink aesthetics. They also give us a chance to notice certain disadvantages of the teeth so that we are able to correct their shape, size and color at this point.11,12 The final shape of the temporary teeth serve as guiding starting point for the dental technicians about the direction in which they should start the workflow in the dental laboratory (Fig.11).

One month later we moved to the next phase - taking final impression. The provisionals were removed and impregnated retraction cords were gently applied. A dual phase technique using condensation silicone was used (Zeta Plus with Oranwash kit, Zhermack, Badia Polesine, Italy). After the evaluation of the impression quality, it was sent to the dental laboratory for production of the permanent all-ceramic crowns (Fig.12,13). The production of the all-ceramic crowns in the dental laboratory was in the following order: scanning the model, computer modelation of the caps with palatal reinforcements, lobbing on CAD/CAM machine, finishing corrections, trying the construction in the mouth, modeling of the porcelain and finally glazing with shading (Fig 14). The final all-ceramic crowns were cemented in the patients mouth using glass-ionomer luting cement (Fuji I,GC,Tokyo, Japan). The static and dynamic occlusion was checked and the necessary adjustments were done. The patient was given complete and comprehensive instructions and was scheduled was regular follow-up examinations (Fig. 15 and 16).

4 DISCUSSION

It is utmost importance to restore the proper lateral occlusion before starting the frontal reconstruction. This is the first thing for the therapist to do if it is not already done. Otherwise, in a short period of time a huge disappointment may follow represented in chipping or breaking of the new ceramic frontal teeth. This clinical phenomenon happens because a patient with a lateral occlusion disability spontaneously uses the frontal teeth for mastication. This way all effort, time and finances are useless. Every compromise with the patients in order to fulfill their wish to make the frontal teeth first and the lateral later ends with guaranteed failure. The chipping/breaking of the ceramic restorations is a very common issue in everyday dental practice and that is why it is a very important theme for discussion (Fig.17).

5 CONCLUSION

The dental professionals should always have in mind that while dealing with dental aesthetics, the psychological self-confidence of the patients plays the most important role. It is not only about treating the teeth, but also about creating a beautiful smile. While trying to achieve perfection in aesthetics it is extremely necessary to balance between the patient's wish and the clinical reality. The smile is created by aesthetic parameters that have been present for many years and they are very useful as tools while reconstructing the teeth in the frontal region. However, to achieve a satisfying final outcome, apart from our knowledge and clinical skills, it takes patience both from us as clinicians and the patients.

Figure 1. Initial situation

Figure 2. Orientation lines


Figures 3 and 4. Simulated and Clinical gingivectomy


Figures 5 and 6. Open gingival sulcuses

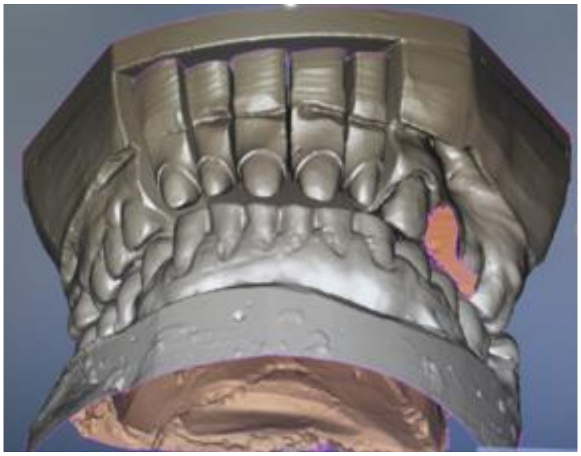
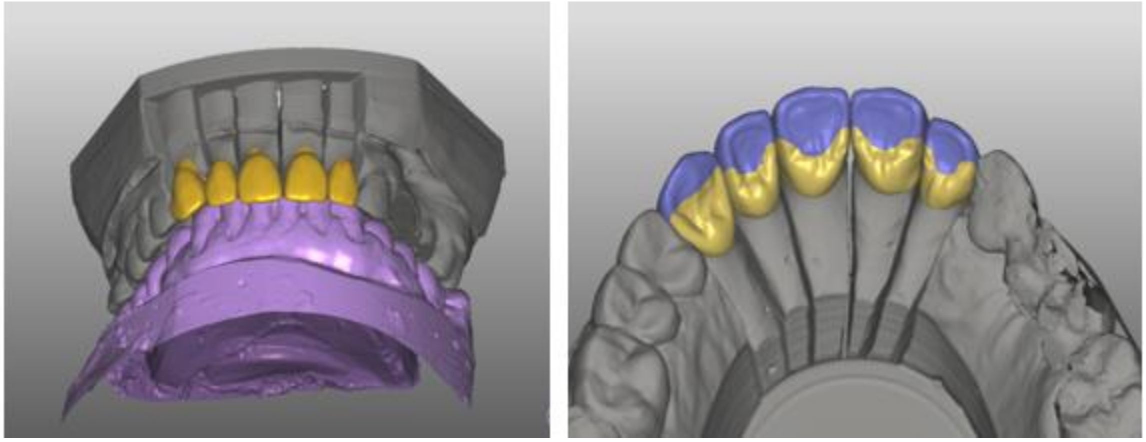


Figure 7. Studio model



Figures 8 and 9. Wax-up modelation

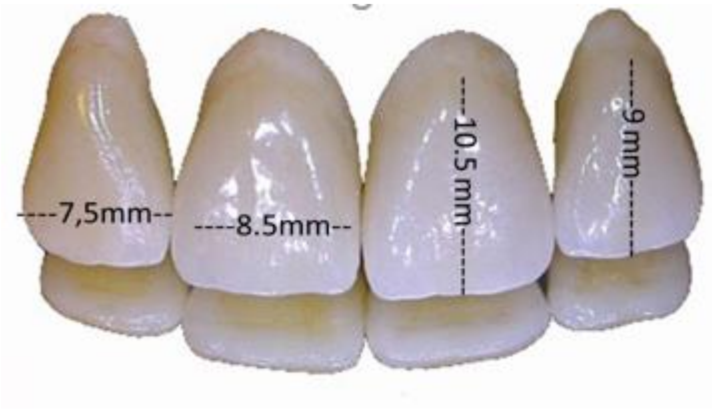


Figure 10. Teeth proportions with in the coefficient values

Figure 11. Provisional PMMA temporary teeth

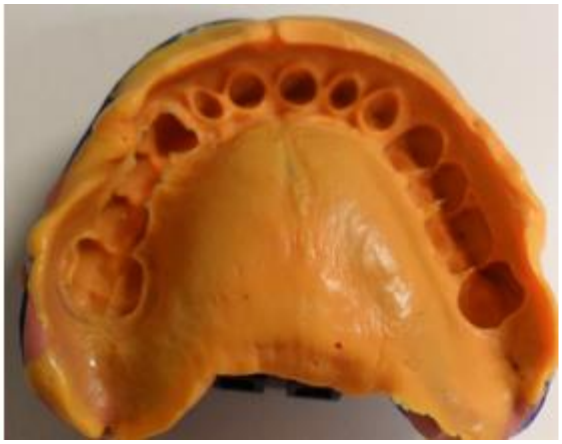


Figure 12 and 13. Dual phase final impression

Figure 14. Fabrication of final prosthetic restoration in the dental laboratory


Figures 15 and 16. Before and after clinical situation

Figure 17. Proper lateral occlusion

REFERENCES

1. M.Robert Mack MR. Perspective of facial esthetics in dental treatment planning. J Prosthet Dent. 1996 Feb;75(2):169-76.
2. Zavanelli AC, Mazaro JVQ, Mestrener SR, Zavanelli RA. Functional and Esthetic Rehabilitation with In-Ceram Alumina and Zirconia System: A Multidisciplinary Approach. J Contemp Dent Pract 2011;12(1):68-72.
3. B. V. Sreenivasan, Murthy and NiketaRamani. Evaluation of natural smile: Golden proportion, Red or Golden percentage. J Conserv Dent. 2008 Jan-Mar; 11(1): 16–21.
4. P.Briggs, A.Ray-Chaudhuri, K.Shah. Avoiding and Managing the Failure of Conventional Crowns and Bridges. Restorative Dentistry Dental Update. 2012 March:78-84.
5. J.F.Weston, E.Haupt. Creating Aesthetic Success Through Proper Clinical And Laboratory Technical Communication. Dent Clin N Am (2011)
6. R.Vellayappan, S.Varghese. Periodontal approach to improve Aesthetics : A Case Report. Journal of Medical Biomedical and Applied Sciences 5(3): 111-113, 2017.
7. L. Musić, A.Ninčević, D.Vražić. Postupci produljenja kliničke krune. Sonda. Sijecanj (2013):77.
8. F.Umer, F.R.Khan , A.Khan. Golden Proportion in Visual Dental Smile in Pakistani Population: A Pilot Study. ActaStomatol Croat. 2010;44(3):168-175.
9. Hasanreisoglu U, Berksun S, Aras K, Arslan I. An analysis of maxillary anterior teeth: facial and dental proportions. J Prosthet Dent. 2005 Dec;94(6):530-8.
10. T.Kulunk. Effects of various finishing procedures on the staining of provisional restorative materials.Journal of Prosthetic Dentistry, 2005:(45-52)
11. G. M. A review of temporary crowns and bridges. Dent Update.1994 Jun;21(5):203-7.
12. Luthardt RG, Stössel M, Hinz M, Vollandt R. Clinical performance and periodontal outcome of temporary crowns and fixed partial dentures: a randomized clinical trial. J Prosthet Dent 2000; 83:32–39.

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