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APPLICATION OF SOLAR ROOF SHALLOW POOL AT INDIVIDUAL RESIDENTAL BUILDINGS

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Abstract. *The paper discusses the possibility of applying shallow roof pools of water on the basis of passive solar water capture functioning as thermal batteries and thermal "regulators" in a "hot - cold" mode with individual residential buildings. With this application, the utilization of the existing functionality of the building roof area would improve and open up the possibility of achieving better overall bio-climate individual object. By using this system, a flat roof impassable "terrace" takes on a new, additional energy function, which proves the ability to reduce overall energy consumption of total conventional seasonal heating and cooling consumption of a building.*
Supporting of this intention, the paper gives a variant solution of an easily prefabricated reinforced concrete roof system of shallow water pool that works on the principle of passive solar energy capture.

Key words: *solar architecture, roof shallow pool, water pool, thermal battery, prefabricated roof pool.*

1. INTRODUCTION

Given the current trend and efforts of most countries in the world towards a common goal to conserve conventional non-renewable energy sources (coal, oil, gas) and in most cases their non-rational utilization, we have witnessed a continuous and increasing degree of pollution of the atmosphere as well as the rapid reduction of existing earth resources. One of the direct manifestations of such negligence is the "devastating" emergence of a permanent increase in the ozone hole in Earth's mantle atmosphere and its overall negative impact on flora and fauna.

With that in mind and the fact that "energy" is a growing problem in many countries around the world from year to year, including the industrialized ones, we all will witness this problem having double counter-effects; on the one hand, energy prices from year to

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year increases, resulting in an increase in prices of other consumer goods, while on the other hand, since the available amounts of fossil fuels are decreasing every day, and that they are harder to reach, a constant appeal for conservation follows, as well as a rational overall consumption. If the current pace of non-rational energy consumption continues, in the near future we will reach a point of complete exhaustion of earth fossil fuels, and therefore what we need now is finding and applying new, preferably renewable energy sources, such as the use of solar energy, geothermal energy, wind, sea, etc. For each under- controlled energy consumption today, will deprive future generations of the basic existence of life tomorrow.

Modern architecture with its flexibility and pluralism is able, without any radical shift as usual, to accept any useful and positive initiative and the application of "solar" energy with all the specific ways of its application and utilization.

With its inevitable breakthrough in architecture, "energy" is only prolonging and enriching the immeasurable design and benefit expressions, and at the same time not inhibiting the basic canons of architectural and construction skills. Therefore, the application of some "energy" resource element on the object should not be considered a "hybrid" inconsistent approach, undermining the basic canonical form of architecture, but should be considered an advantage of its well thought architecture and the inevitable evolution towards better, just as a man's culture, with his true value will always remaining permanently within us.

Overwhelming permeation ratio of energy in architecture is of "recent" date, and as a new guideline, refines more and more the architecture of the building builder, constantly refining it with one hand, applying new materials and their properties with new construction techniques, and on the other hand emphasizing the importance of "New Quick Start" system applicable for all types of energy in the primary function of holding an object in space.

Energy system in architecture, with its entire awkward-installer network, is not treated any more as a "necessary evil", but it represents the soul and encourages new forms in the further upgrading of modern architecture. So the "energy" has become in certain circumstances the primary structure factor and the new architectural alternative to "maintain" not only the heat of climate regimes, but also the whole "body" object.

In recent decades, contemporary architecture gives growing importance to direct application of renewed energy sources, particularly in their use of active and passive solar project, having in mind their functional vital feature, giving them an equal place and role with other construction materials and elements in the design process.

2. THERMOACCUMULATIVE ROOF SHALLOW POOLS

In parallel with the development of "Trombe wall", the "Skytherm System" was developed by Harold Hay. The basic idea of the "Skytherm System" was based on the principle of passive accumulation of a daily captured solar energy by the "shallow" water umbrella "containers" (baths, pools) placed over the roof of "flat" or ceiling panels in the function of "heating-cooling" indoor facility. With its dual functions, the roof "containers" or shallow pools, at the same time serve as an umbrella "cover" and the "heating-cooling" system.

Roof barrel "containers" or shallow water pools, set on the roof "flat" panel object can be made of concrete elements, metal or plastic prefabricated containers. Depending on the system construction, they can be placed over the corresponding tin-steel support structure or concrete pillars. "Regular" water is used as a working fluid for this system.

Heat absorbed in roof "beds" during the day, is directly transmitted in the lower dwelling object space, reaching a temperature level of 21°C in winter. The thickness of the layer of water in shallow pools should not that "great" for thermal reasons. The usual thickness of the layer of water in the pool should range from 15÷25 cm. In Fig. 1 and Fig. 2, there is a flow chart of a prototype of the original idea of work "Skytherm Systems" in the mode of summer- winter functioning regime.

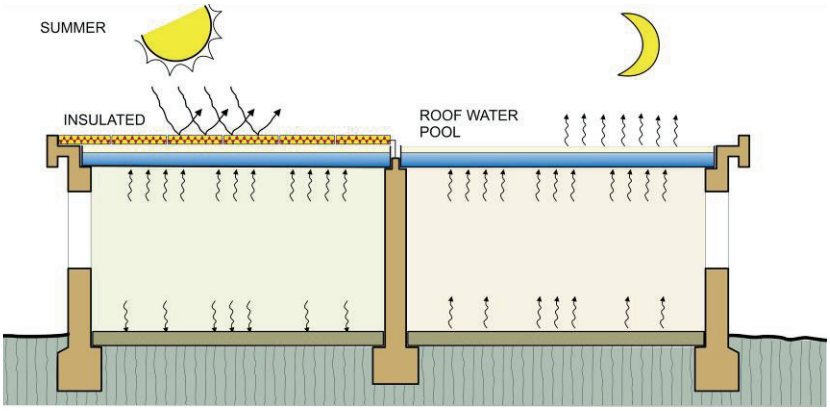

Fig. 1. The working principle of the roof storage system in the daily summer cooling mode.

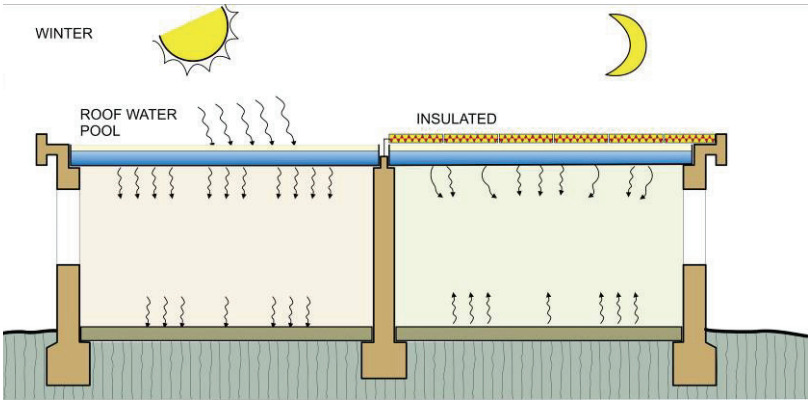

Fig. 2. The working principle of the umbrella storage system in the daily winter accumulation and giving away heat mode.

In geographic locations where the angle of the sun is too little in winter, the effectiveness of the system functioning will be significantly reduced. For these reasons, their application between 35° north and 35° south latitude is recommended. At these latitudes, the sun is slightly higher in the sky during the winter season, and thus the efficiency of the system utilization is significantly higher. This implies that the main purpose of this system would be the "cooling" of the interior space object during the day, as this is far more necessary is such climates than winter warming.

3. APPLICATION OF PREFABRICATED REINFOCED CONCRETE SHALLOW ROOF POOL

In order to rationally use the final flat roof surface of individual residential buildings which is in most cases constructed as "impassable" roof terrace, we have developed a system of prefabricated roof applicative tehermoacumulative shallow pool of water on the basis of reinforced concrete "shell" along with flexible construction.

The system can be applied in different individual base structure dimensions. The spatial size of the "unit" roof of shallow pools of water largely depends on the object, i.e. the arrangement of load-bearing walls. In Fig. 3, an alternative "arrangement" scheme of the roof of the shallow water pool with "variant" outer loading surface for benchmark square and rectangular objects is given.

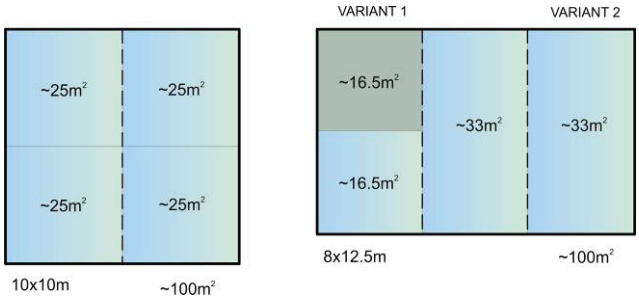

Fig. 3. Variant layout "settings" of the shallow roof pools benchmark facility.

In Fig. 4, the scheme of setting variant direction of the roof covering the shallow pools of water with the folding thermo accumulative rigid thermal insulation boards is given.

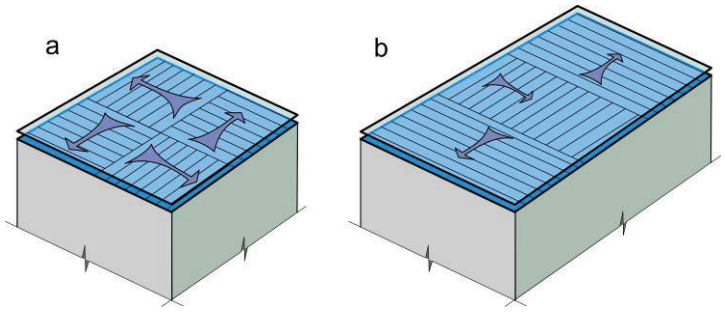

Fig. 4. Variety direction "covering" the folding insulating blanket.

The overall efficiency of "accumulation" of solar heat of roof shallow pools of water depends on many influencing factors. One of the main factors is the "use" of the water level "depot" in the pool. Experiments have shown that the thickness of the water "depot" in the pool should be in the range of 15 ÷ 25 cm, in order to achieve maximum system performance. The graph (see Fig. 5) gives a graphic illustration of the ratio between the volume of the water depot (m^3) variant and the corresponding height (h) of the water depot roof pool, compared to the "extra" load floor construction facility.

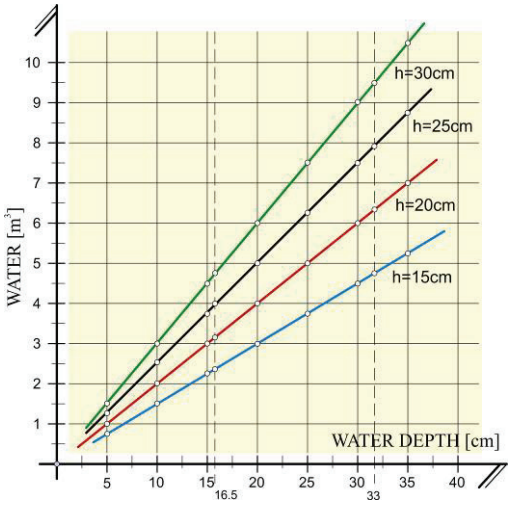

Fig. 5. Graph of the ratio between the volume of the water depot shallow roof pools and deep water layers of the depot in the pool.

The prototype solution of the cover shallow pools of water provides two versions of the assembly "lamella" bed with "flexible" length (L) design to 5m. In Fig. 6, an overview of the basic variants of mounting "blades" pool bed without the bottom "ribbed" reinforcement is given. In this variant the "trough" can installed over the final floor slab of the flat roof building. Lamella bed width (B) is envisaged in the range of 50÷60 cm.

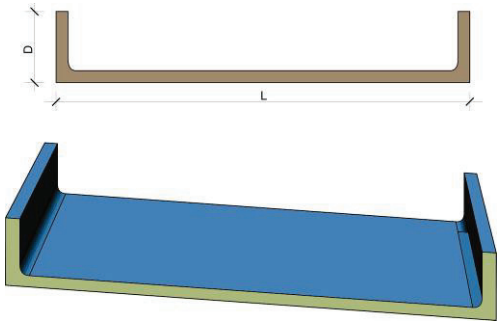

Fig. 6. The scheme "blades" of a prefabricated shallow bed of the pool without a roof base reinforcement.

In Fig. 7, an overview of other "enhanced" versions of prefabricated roof of shallow troughs of the thermo accumulative water pool is provided. In this variant an additional reinforcement has been done on the "lower" base plates and the riverbed next to the function of strengthening, achieving a "tape" between the ribs which can be used to fill additional insulating layers. The distance between "lower" reinforced ribs (L_1) depends on the final total length of the mounting plates and is moving in the range of 120 ÷ 180 cm.

Thickness of the "body" of prefabricated bed pool in both variants is 7 cm with a built-in appropriate constructive reinforcement. Above the water depot in the pool the setting of a removable (rolled) transparent plastic membrane that has a dual function is also foreseen. The function of "creating" a protective air "hot" pad above the water depot and the function of protection against unwanted application of various "deposits" from the air. The distance of the transparent plastic membrane from the surface of the water depots should be moving in the range of 10÷12 cm.

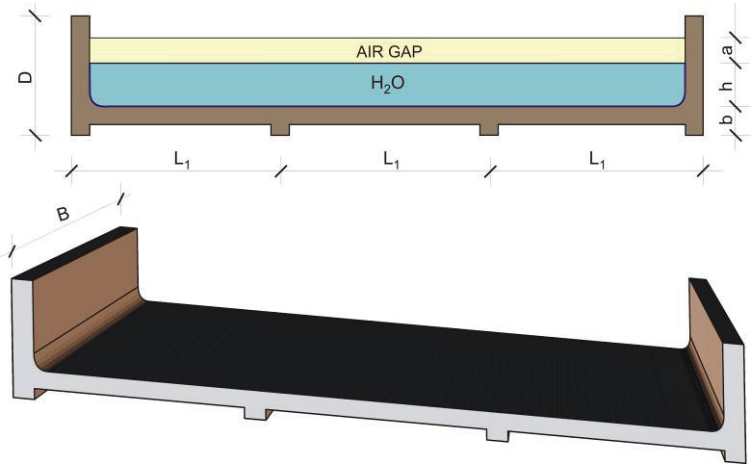

Fig. 7. Variant with reinforcing the bottom base of the prefabricated shallow pool roof.

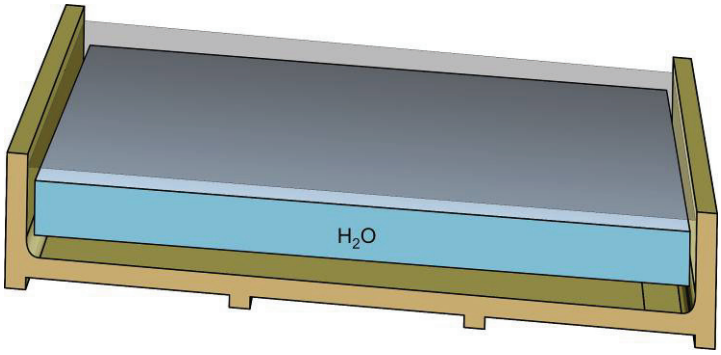

Fig. 8. Spatial view of prefabricated reinforced roof segment thermo-accumulative shallow water pool.

In Fig. 8 the schematic representation of the spatial variations of prefabricated roof reinforced with a shallow bed of the lower base pan is given. Protective transparent plastic membrane that is placed above the surface of the water depot can be removed (rolled) in terms of "needs" of specific conditions. In case of rain, transparent membrane can be "moved" (rolled) or not, depending on whether we want to protect the pool of "excess" water filling and unwanted "extra" cooling water depot.

Each umbrella "unit" of the roof assembly shallow pools is designed and the "security open drain" in case of overcharging the pool water due to rain or other natural disaster (see Fig. 9).

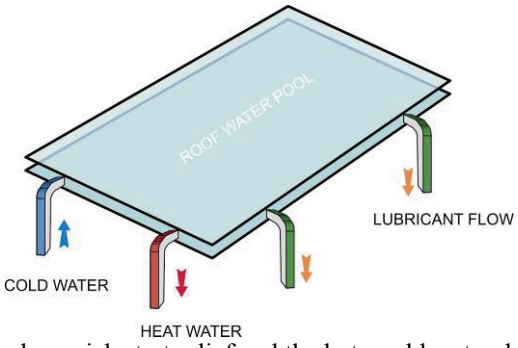

Fig. 9. Scheme of display quick start relief and the hot - cold water drains on the roof mounting shallow pool.

In Fig. 10, the scheme of the longitudinal section through the trough assembly of the roof of shallow water pool with a review of basic applied elements is given. The shell bed is made of reinforced waterproof concrete which is lined inside by the impermeable secure waterproof foil. Placed over the insulation is a metal pool ("stainless steel") or plastic trough which must be coated on the inside with a black absorption color or spectrally selective coating which is applied for this system with the absorption of the emission of 0.95 and 0.05%.

Legend:

1. folding insulating protection.
2. transparent PVC folding.
3. air safety buffer.
4. water deposit pool.
5. " Stainless " steel trough.
6. waterproofing foil.
7. reinforced concrete trough.

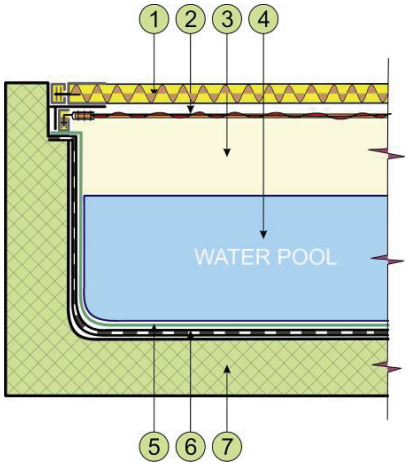

Fig. 10. Detail of the longitudinal section of thermo-accumulative shallow pool roof prototype.

By using spectrally selective coatings and spectrally selective films set via the "stainless" metal bed greatly improves the water absorption performance of the thermo-accumulative depot treatment in relation to the ordinary "black" coating.

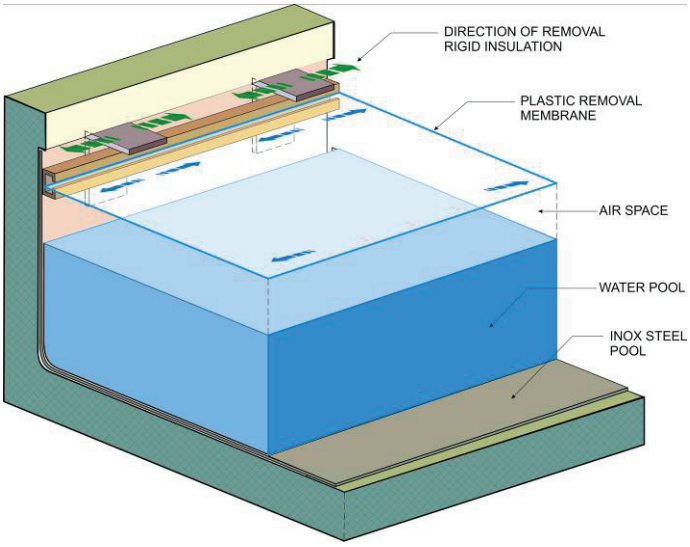

Fig. 11. Spatial angular segment display detail of the roof assembly prototype thermo-accumulative shallow pool of water.

The main feature in the application of the roof assembly is characterized by shallow pools of water in its application to different light conditions on the ground, ie. on the site. The system can be set up (install) on a previously designed flat roof and can also be applied in the construction of the ceiling finished panel. Their spatial dimensions can be easily mounted on any existing flat roof area.

3. CONCLUSION

By using prefabricated roof thermo accumulative shallow pools on the "one" part of the existing built stock of individual housing units where as the "final" roof surfaces made "impassable" roof terrace, one can greatly improve the existing bio-climate to beneficiaries of such spaces. Viewed from a position of energy-economic savings, the implementation of this system would improve the reduction of the total "pie" of every object in the consumption of conventional energy and heating-cooling mode; the season would significantly reduce the need for regular consumption of conventional energy sources.

The spectrally selective absorption surface applied of the shallow water pool provides substantial "benefits" for its efficiency of utilization of performance in relation to the application of other traditional "red" or similar coatings. This system also allows for more functional usage and transformation in the way of direct utilization by individual building owners.

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PRIMENA SOLARNOG KROVNOG PLITKOG BAZENA KOD INDIVIDUALNIH STAMBENIH OBJEKATA

Dragan J. Gavrilović, Jasmina Stojić

U radu se razmatra mogućnost aplikativne primene krovnih plitkih vodenih bazena na bazi pasivnog solarnog zhvata u funkciji vodenog termo akumulatora i termo "regulatora" u sistemu "toplo-hladnog" režima kod individualnih stambenih objekata. Ovakvom primenom, unapredila bi se postojeća funkcionalnost iskorišćenja krovne površine objekta i otvorila mogućnost u ostvarenju boljeg sveukupnog bioklimata individualnog objekta. Primenom ovog sistema, ravna krovna neprohodna "terasa" dobija novu, dodatnu energetsku funkciju, kojom se ostvaruje mogućnost u smanjenju ukupne sezonske konvencionalne potrošnje energije za grejanje i hlađenje jednog objekta.

Kao prilog ovoj intenciji, u radu se daje prikaz jednog varijantnog rešenja lako montažnog armirano betonskog sistema krovnog plitkog vodenog bazena koji funkcioniše na principu pasivnog zahvata solarne energije.

Ključne reči: *solarna arhitektura, krovni plitki bazen,vodeni bazen, termo akumulator, montažni krovni bazen*