

THE CONCEPT OF ECOLOGICALLY SENSITIVE RESIDENTIAL DEVELOPMENT FOR AREAS AT RISK FROM NATURAL DISASTERS

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Summary

Climate change has dramatically increased the frequency of natural disasters that destroy ever-larger areas inhabited by people. Thus, a complete change of spatial planning conception is needed.

This paper aims to describe the technical capabilities of ArchitrAdom, an innovative construction and architectural project. The structure has been designed for use in areas at risk from natural disasters: floods, hurricanes and earthquakes. It eliminates the drawbacks of traditional residential developments, which is not disaster-resistant. This project allows for whole urban organisms to be build.

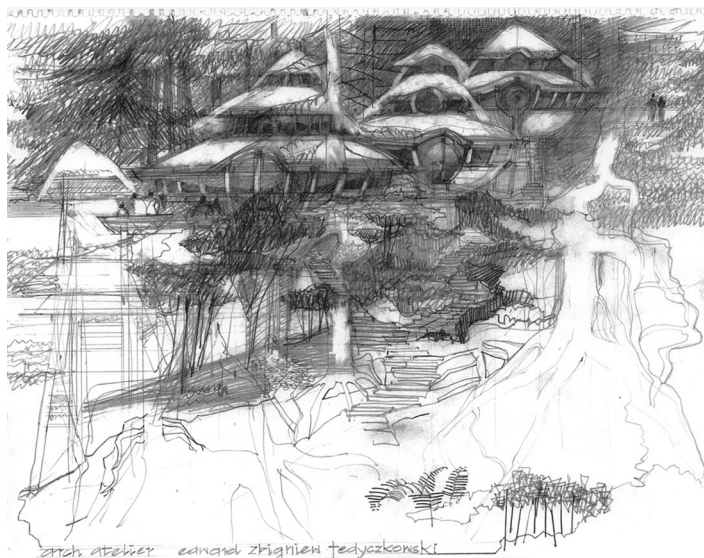
The project's focus is on elevating usable area above the surface of the flooded terrain and shaping the building; as to make it as resistant to wind force as possible. The other key aspect is the integration of the structure by means of lines and bands which increases the buildings resilience. The advantages of ArchitrAdom are:

- resistance to natural disasters and the effects of climate change,
- various adaptations: residential establishments, public utility buildings, public space, etc.,
- significant flexibility in forming groups of buildings: villages, housing estates, quarters, towns, etc.,
- the highest respect for rules of sustainable and ecological design,
- an advantage in advanced prefabrication to minimizes costs.

Keywords

elevated structures • natural disasters • climate change • prefabricated structures • elevated infrastructure • sustainable architecture

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Drawing by Fedyczkowski

Fig. 1. ArchitrAdom. Minimal interference with the ground

1. Introduction

The rising number of countries and regions that are or could be interested in resistant constructions to water and force wind events will increase. This is due to climate change, global warming and the increasing frequency of natural disasters. Floods are covering larger and larger areas. At present, most of the European countries have been subjected some form of a to natural disasters.

North America is the continent of annual natural calamities. New Orleans, Florida, California and over twenty-five other states are seasonally stricken by hurricanes, floods, tornados and earthquakes [Graniczny and Mizerski 2009, Fischetti 2013].

Latin America every year falls victim to hurricanes, earthquakes and floods, especially the Caribbean and the Gulf of Mexico [Tiballs 2005, Nicholls et al. 2007]. The same applies to South America.

Japan is affected by earthquakes and tsunami on a regular basis. Every year, huge floods strike China, India, Thailand and other Far East countries that are under constant threat by tsunami. Russia has recently suffered extensive floods.

Water has devastated almost every region in the world [Kundzewicz and Kowalczak 2008]. The list of countries not stricken by the effects of natural disasters is much shorter. Poland has also started to feel the effects of climate change, for example, there has been an increased amount of floods.

All the fore mentioned nations and regions would surely be interested in the response of architecture, urban studies, and spatial planning and management to natural calamities.

2. Research methods and area of study

Doctoral student Zbigniew Edward Fedyczkowski, under the guidance of Professor Waław Seruga, writes a doctoral dissertation: "Concept of development for areas at risk of natural disasters" at the Faculty of Architecture of Kraków University of Technology (the Institute of Urban Planning, Department of Residential Environment Planning).

The area of study is the development of a structure resistant to most of natural disasters and allowing construction of housing estates. The building, an innovative architectural and construction project ArchitrAdom – is also a leader in ecological and sustainable architecture (Figure 1).

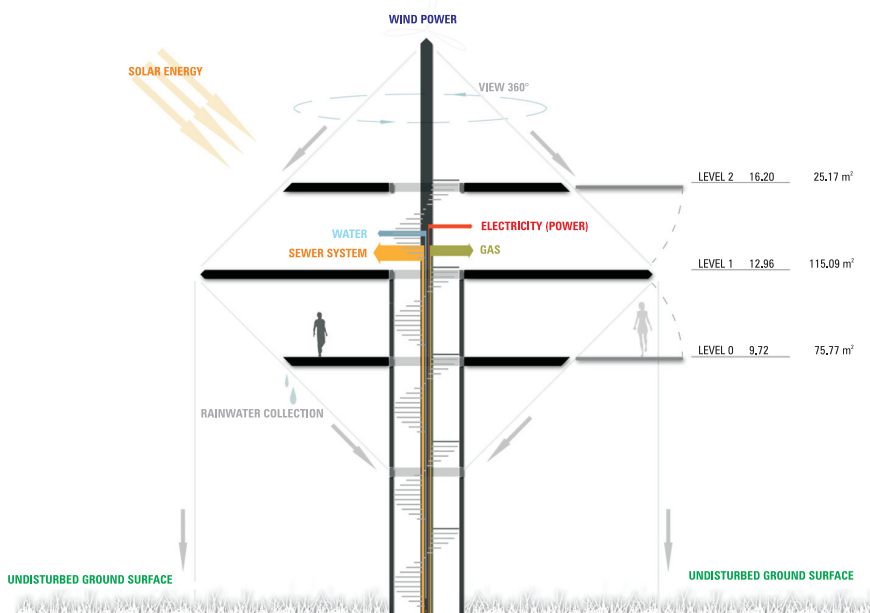
3. The advantage of the project

After having compared ArchitrAdom to traditional buildings and structures in different conditions and surroundings, the following advantages can be determined:

3.1. Ecological aspect

ArchitrAdom is also designed for safe areas. Ecologically, it is the most advanced structure among both existent buildings and those still in the project phase. The ecological responsibility of the project includes technology, construction, architecture, assembly solutions, as well as spatial management. The advantages of the structure combine basic benefits for residents (lowering media costs) with a wider-scale support of nature and creating a human compatible environment (Figure 2):

- Environment – minimal interference. The only interference – consists of supporting the stem with sides of length 2.5 m. The foundation does not exceed much over this circuit. The lines a fixing ArchitrAdom to the ground have virtually no impact on nature. In case of assembling the stem in water, the water bottom environment is not disturbed.
- Heating cost – low. Heating is supplied by modern heating systems, for example obtaining energy from a solar thermal collector placed on the roof. A symmetrical construction of the building facilitates a uniform distribution of heat and lowers cost of installation. Moreover, the very shape of the building minimizes heat losses thanks to the little use of vertical surfaces, which are most susceptible to cooling.
- Ease of rainwater harvesting. The pyramid-shaped surface of the roof allows for storing rainwater in containers with a tight filter. Thus gathered water can be a supply of drinking during natural cataclysms or it can be used on a daily basis. Water from municipal pipes is supplied only after the container has been emptied. That way the use and costs of water are significantly lower.
- Renewable energy – a simplified use of solar, wind and water power. Solar thermal collectors placed on the roof are exposed to sunlight throughout the day. The wind-mill on the top of the building is highly efficient thanks to its height – it is placed at least 10 meters above ground.



Source: authors' study

Fig. 2. The scheme presents ecological aspects of ArchitrAdom (the use of renewable energy, rainwater harvesting, point foundation which saves the ground space) and a convenient way of supplying media. Also pictured are the outside lines, which serve as an additional stabilization to the building

- The amount of materials – the foundation foot is much smaller than in present-day structures of similar size. The amount of covering material and the interior finish materials is also considerably lower.
- Built-up area occupies approx. 6 m² and usable area – 215 m². The rest of the plot is an undeveloped area that could constitute green area for recreation, gardening and other cultivation works, circulation and parking area, storing place, etc. After extending, the roof onto the ground, the space becomes an integral part of the building (serving as a garage, hobby area, etc.). Yet it should be noted that it can be flooded in time of flood. If ArchitrAdom is to be built on water, it can serve as a berth for boats. The space thus gained multiplies the amount of green area. Nature “gains” almost the complete ground level and all the development is above. Keeping an appropriate distance between single ArchitrAdoms, at a housing estate ensures access of sufficient light for an abundant plant growth.
- Green walls – trees are the main “neighborhood barriers” in the concept of ArchitrAdom estate, shielding residents from view from the windows of the other building. Planting trees on the ground is thus highly recommended for functional reasons.

- Safe for water environment. Artificial islands in Arab and other countries irretrievably destroy the seabed environments and kill any forms of life there. This interrupts the ecosystem and stops the process of natural cleaning of water. As a result, luxury estates on artificial islands are not habitable because of poisoned water and the stench from the sea. The ArchitrAdom solution enables construction of whole estates on water without interfering with natural the cycle of the sea environment (Figure 3).



Drawing by Fedyczkowski

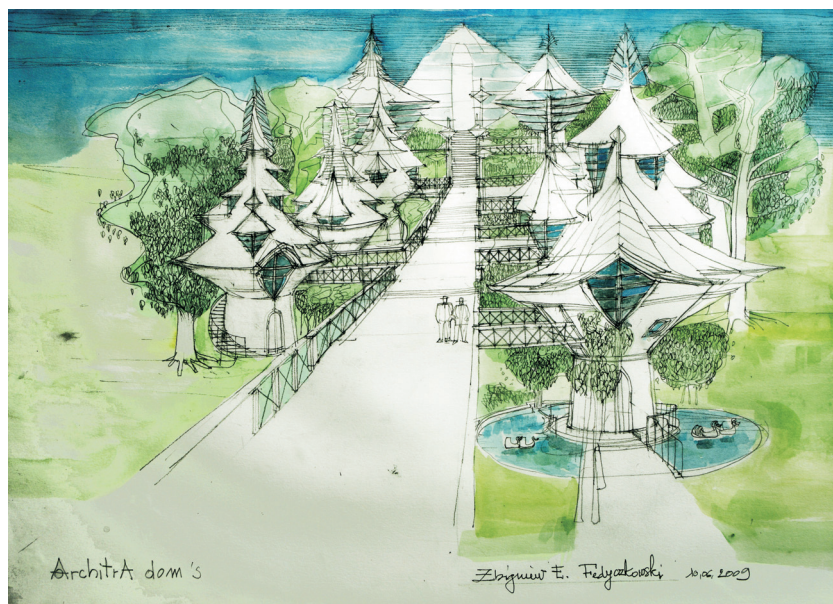
Fig. 3. Models of an ArichitrAdom housing estate in a bay in British Columbia, Canada

3.2. Economical aspect

ArchitrAdom is a prefabricated construction, yet the method avoids many typical problems of the present prefabricated construction industry. These would be repeatability of form and no possibility of customization of the building by its owner. The additional advantages are:

- labor costs: lowered by 50% to 80% (depending on the type of finish) as the result of maximum prefabrication,
- costs of materials: 60% lower in comparison to structures build by traditional means,
- 80–100% of all building elements, as well as assembly of electric, water and gas installations, can be manufactured at manufacturer's facility; this allows for significant increase in quality control of manufacturing,
- supplying: by a truck, barge or helicopter; a small residential unit (ready to be moved in) can be transported by a helicopter,
- assembly and construction: reduction in installation time of 20–30% of traditional means of construction,

- use of energy; decreased by 30% in comparison to the now-available technology; the reduction of need for heavy equipment,



Drawing by Fedyczkowski

Fig. 4. ArchitrAdom housing estate with passageways placed above the ground. Such estate can function in an almost ordinary way even in times of flood

- ArchitrAdoms can be placed in the shallow waters of seas, atolls, swamps, and temporarily flooded areas,
- the possibility to develop the area on a larger scale (Figure 4); single buildings can be arranged into housing estates of any kind, including the necessary infrastructure and social and commercial facilities which can occupy relatively more space than in case of traditional development.

3.3. The results of the research

ArchitrAdom is an elevated structure of a maximal integrity, resistant to natural disasters. Due to the elevation off the ground, it can avoid contact with water and, as a result, it is the only building likely to survive a flood. The construction is sturdy enough to endure winds much stronger than ever recorded. Moreover, due to the maximum stability of its construction, ArchitrAdom is resistant to earthquakes.

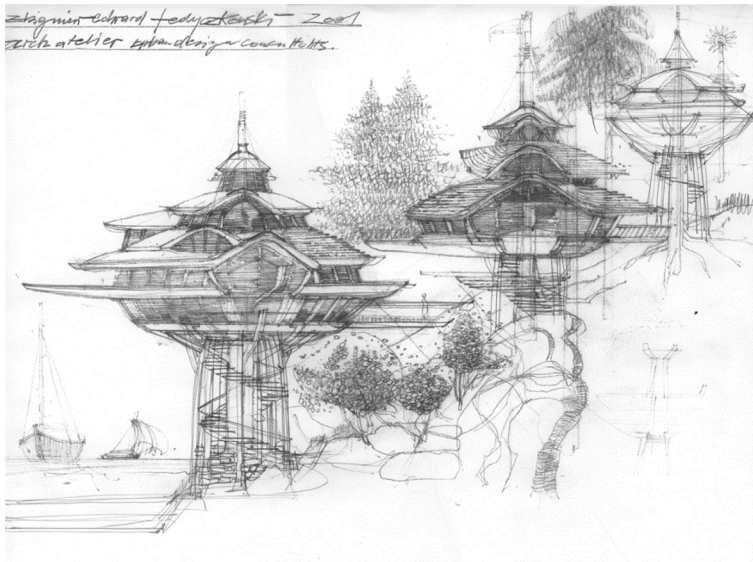
ArchitrAdoms can be placed in areas that are inaccessible to traditional buildings: in bodies of water, shallows, waterlogged areas, unstable grounds, areas of high slope,

or on rocks (Figure 5). They can be built in areas threatened by natural cataclysms. The project focused on minimizing costs, the rules of sustainable design, and aesthetics.

The strength of ArchitrAdom solution is its incomparable universality in different versions:

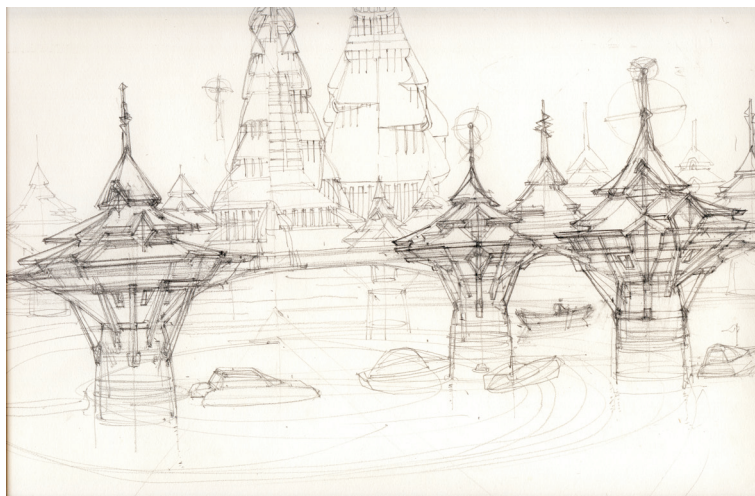
- the basic version is easy to transport, designed as shelters for victims of natural disasters,
- for the populations who become homeless, as the result of territorial conflicts and wars,
- for medical staff in regions of temporary or permanent destabilization,
- for the UN personnel, peace missions or other groups,
- on the medium level, for clients wanting to live above water or on terrain temporarily flooded by heavy rainfalls; this version could be designed both in modern (Figure 3) and traditional styles (Figure 4); these would be easy to assemble using natural resources even by inexperienced labor; these structures can be a solution to many of the threatened regions in Poland and worldwide; and they can blend-in with traditional homes.

ArchitrAdom can solve basic housing problems in Poland, as to well as serve as a perfect export product, innovative on a global scale.



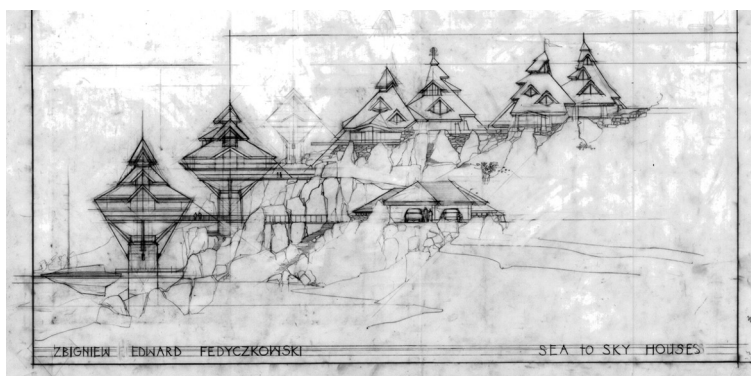
Drawing by Fedyczkowski

Fig. 5. ArchitrAdom, an example of housing development at a rocky shore in British Columbia, Canada



Drawing by Fedyczkowski

Fig. 6. An example of the use of ArchitrAdom. Modern housing estate located on water, with bridges connecting the structures with the mainland



Drawing by Fedyczkowski

Fig. 7. An example of the use of ArchitrAdom. A diverse estate kept in the traditional style, located on a rocky shore

4. ArchitrAdom – a short technical description of the structure

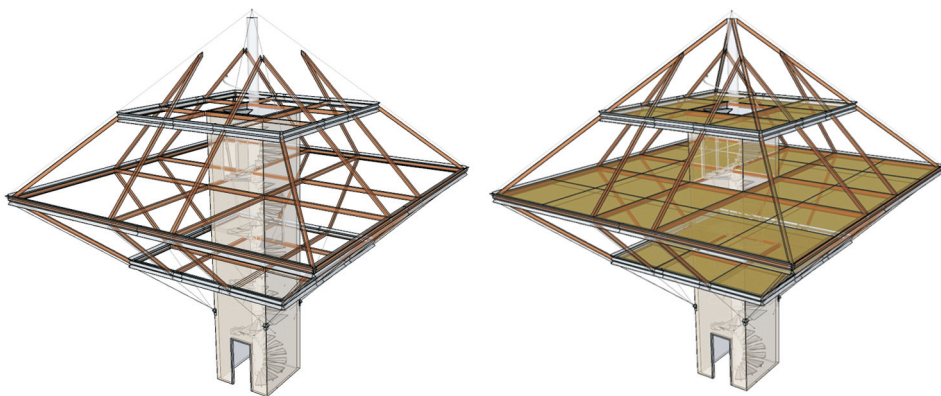
The building process mainly consists of a quick assembly of prefabricated modular elements in combination with natural, human friendly resources (such as wood, glass, stone, etc.).

The base of the building consists of a stem with a square cross-section of 2.5 m side (other options with polygonal cross-sections are also in preparation). The stem can be

made of wood, aluminum, steel or concrete. It is installed on a foundation system. Also, it can be installed as a temporary structure, for example, on a flooded terrain. Inside the stem, a spiral staircase is located and access to all media is provided. The whole stem is one prefabricated item, transported to the construction site by a helicopter, truck or barge.

The stem is mounted vertically by means of a crane. After installing beams and fixing them with lines, the structure is ready for finishing work. The lowest level is elevated, a few meters above the ground, above the anticipated level of the highest flood wave. Consistency of the structure is ensured by lines which connect beams with the stem [Bach 1975]. Additional, external lines integrate ArchitrAdom with the ground. [Otto et al. 1976].

Shape of the building: The basic shape consists of two pyramids connected by the bases and forming a square base. It is a compromise between user-optimal usable floor space and minimizing the impact of strong winds, violent flood waves, the effects of air currents caused by tornado or seismic shock (Figure 8) [Burkhardt 1975].



Drawing by Fedyczkowski

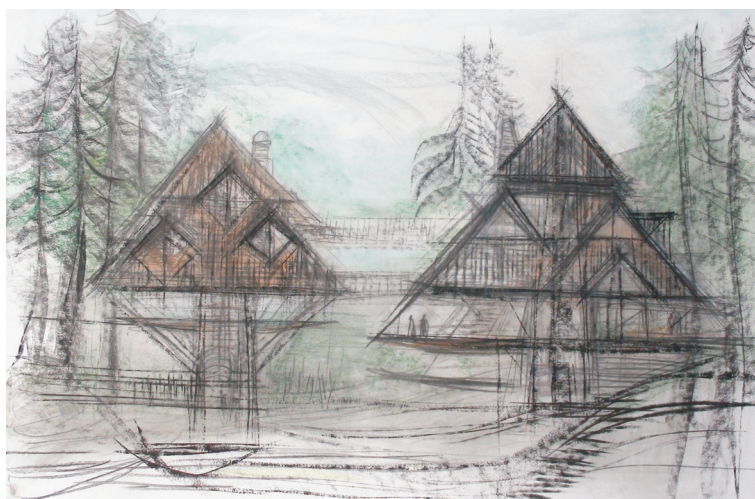
Fig. 8. ArchitrAdom models presenting outline of lines and rafters in the construction

5. Conclusion

ArchitrAdom is a perfect solution for the countries exposed to tornadoes, hurricanes, tsunami, earthquakes and floods, due to the increased integrity of the structure. The main advantages of the project are:

- Ecology-wise: it is now the most advanced structure (in terms of technology, construction and architecture) by lowering heating cost, ensuring easy rainwater harvesting and encouraging the use of solar, wind and water power. The negative impact on the environment is minimized during both the construction phase and utilization of the structure.

- It has a high resistance to climatic threats and cataclysms.
- The various advantages of the innovative, prefabricated construction; such as lowered costs, a quicker construction process and the possibility of customization by its inhabitants.



Drawings by Fedyczkowski

Fig. 9. Suggestions for land development of Podhale and other regions of Małopolska. Architrads designed in folk style, on water and on shore. On the area threatened by flood, usable space should be elevated to a safe level. If the area is not at risk of natural disasters, roof space can be extended onto the ground and underpinned, thus giving resemblance to a traditional house

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