

THE TECHNICAL AND ECONOMIC ANALYSIS OF DIFFERENT CONSTRUCTION SOLUTIONS FOR SPORTING GROUND SURFACES

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- costs of making sporting surfaces

Abstract:

Adequately constructed and furnished sporting grounds and facilities are needed to promote sports. In the recent years, we have witnessed a rapid development of sport facilities, supported by the EU funds. New technical and technologies solutions have appeared. In order to provide better conditions for the pursuit of various sports disciplines, sporting grounds are constructed using different safe and durable surfaces, which present different technical parameters and incur different construction costs. This paper discusses the most popular surfaces made of grass, artificial grass, polyurethane and acryl. They have different technical properties and can be used to practice different sports. The construction costs have also been compared as well as the maintenance costs, which are particularly important in facilities designed to last many years. Four solutions of sporting ground surfaces have been designed to analyze the details. For costs analysis, estimates have been made with the educational version of the NORMA PRO software. Maintenance costs and costs of some building materials were found in information brochures made available by manufacturers and developers of sports facilities. The summing-up specifications, apart from the costs, show the most important characteristics of the described solutions, their advantages and disadvantages. The performed analysis proves that although there are certain pros and cons to each of the analyzed solutions, all of them can be successfully used in different types of sports facilities.

INTRODUCTION

The Building Law [9] defines the notion of a building object (Art 3 Point 3) which includes buildings, building structures and small architectural objects. Subsequently, it lists types of constructions, including sports constructions. The Act on Building Law classifies all sports facilities to category V of building objects and provides a list of examples in the Annex to the Act, e.g. stadiums, amphitheatres, ski jumps, ski lifts, outdoor swimming pools, slides. In turn, the Polish Classification of Types of Constructions (PKOB) includes sports facilities in Section 2, Division 24, Group 241:

- sports grounds and sports building objects: managed sporting grounds for open-air sports, e.g. football, baseball, rugby, water sports, athletics, car races, bicycle races, horse races;
- other sports and recreational facilities: amusement parks, relaxation parks, other outdoor facilities, e.g. skiing trails and tracks, drag lifts, chair lifts and cable cars – permanently fixed; ski jumps, toboggan tracks, bobsleigh tracks, golf courses, sports airfields, horse riding

schools, marinas, beach and bathing facilities, water sports facilities, public gardens and parks, green squares, botanic gardens and zoological gardens, animal asylums.

Among the constructions mentioned by the legislator there are a number of such facilities needing special surfaces, without which specific sports disciplines could not be practiced. It is the choice of an appropriate surface that is among the most important decisions taken while planning to build a sports facility. Depending on the designed function, the surface must have high resistance to wear or must ensure good ball-bouncing. The location of a given surface may necessitate adequate water permeability or resistance to atmospheric conditions [4].

For many years, sports grounds, pitches, tracks and racecourses have been built to do sports. Traditional grounds for most of sports have been designed with natural grass turf and - whenever good ball bounce was needed – traditional concrete or tarmac surfaces were made. Running tracks were made from slag or gravel. At the moment, traditional solutions are replaced with new technologies. Artificial grass surfaces are made instead of natural grass. Polyurethane and acrylic surfaces have been invented. All these surfaces are versatile and have gained much popularity.

SUBSTRUCTURE

All surfaces, to guarantee their good work, must be composed of several layers which by interacting with one another ensure adequate load transfer. Layers of substructure are laid on the subsoil, and finished with layers of the proper surface. When raising sports facilities, different types of surface need different types of substructure [5, 6].

The simplest solution is to make a base from natural or crushed aggregate. Such substructure is constructed by laying and compacting subsequent layers. Because of the properties of aggregate, this substructure is water permeable. It is used under football pitches with natural and artificial grass surface and under polyurethane surfaces. It is extremely resistant to atmospheric influences. It is a dynamic type of substructure, used in outdoor facilities.

Stiff base is often made as concrete substructure. It is used in both indoor and outdoor constructions. Because of its high rigidity, it must be made with dilatations. It is less resistant to atmospheric conditions and therefore, in open-air facilities, line drainage must be made. It is most often prepared under tennis courts, athletic tracks, sports halls, basketball courts.

Asphalt cement substructure is used in outdoor facilities. It is more elastic and resistant to atmospheric conditions than concrete base and guarantees long life and stability of surfaces. It is either hardly permeable to water or completely impermeable, which necessitates building a line drainage system. It is most often made under tennis courts, athletics tracks, basketball courts and multi-purpose sports grounds.

Polyurethane substrate is the highest quality, modern substrate, which ensures high safety to sportsmen. It is laid together with polyurethane surface using a specially designed paver. It is characterized by high water permeability, does not break or crush, does not need dilatations. It can be used for outdoor and indoor facilities, under multi-purpose sports grounds, football pitches, tennis courts, athletics tracks and playgrounds.

SURFACES OF SPORTING GROUNDS

Pitches and tracks for different sports disciplines are covered with suitable surfaces. They must meet the requirements, e.g. ensure good ball-bouncing, safety when a player falls or adequate dynamics when jumping.

NATURAL GRASS PITCHES

For many years, the most popular surface for football pitches has been natural grass. At present, when building a sporting facility with natural grass it is possible to use a ready-made product such as rolled grass, or sow grass seeds [7, 8]. However, a purpose-made choice of grass mixes, dense and strong root system and quick self-regeneration of the surface which rolled grass ensures makes it the best option. A full-size pitch cover can be assembled from rolls of grass in a few up to two weeks; alternatively, it can be sown in a day, followed by 6 to 8 weeks for the grass to root and the pitch is ready to play on after 3 months. The base is made of a layer of gravel and sand or a layer of fertile soil, which ensures good water draining to a drainage system and proper grass growth. Depending on individual needs, it is possible to install an automatic system of sprinklers or a heating system under the pitch.

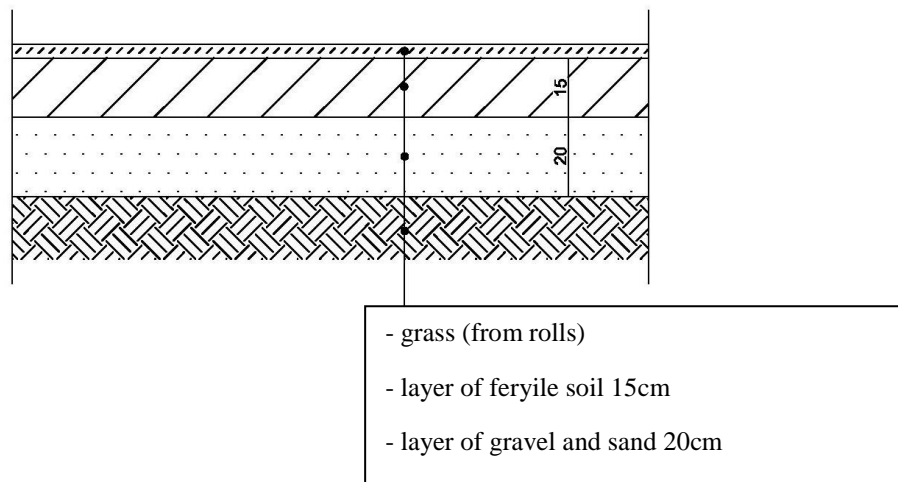


Fig.1. Construction of rolled natural grass surface, source: authors; Source: authors based on [1,2,3].

It should be remembered that, irrespective of the size of the stadium pitch, its grass surface cannot be used for more than 5 to 6 hours a week, which in practice is a considerable time limiting factor. When the above time limit is exceeded, the vegetative system of grass is out of balance and the grass loses its ability to self-regenerate. Natural grass must be given regular care. Mowing, watering, aeration, sanding, fertilizing or rolling are the necessary treatments, which guarantee that the grass surface will be maintained in good condition and no need for repairs or complete replacement will arise. Despite the above nuisances, natural grass is still the most popular surface on football pitches.

ARTIFICIAL GRASS SURFACES

Synthetic grass is one of the most attractive and functional solutions for sports grounds and courts. It is made from resistant and durable materials, which means that a pitch or track with artificial grass surface will retain its aesthetic and elegant looks even when used intensively. The main advantage of synthetic grass is its durability and resistance to atmospheric conditions and UV radiation. It can be used all year round. It is laid on polyurethane substructures, dynamic substructures made from rock aggregate and on concrete and asphalt cement bases. Artificial grass surface is composed of polypropylene and polyethylene fibers of different thickness and height, embedded in a 2-mm thick layer of latex. The basic parameters such as grass height and density allow the designer to make an optimum selection of the type of surface to the sports discipline to be practiced. For players, artificial grass creates conditions similar to these of natural grass (with no time limit of play, in any season of the year), but the maintenance costs are much lower. Owing to such qualities as water permeability, resistance

to atmospheric conditions and high elasticity, artificial grass surfaces can be used on football pitches as well as handball and volleyball courts. There are also tennis and badminton courts as well as rugby and multi-purposes playing grounds covered with synthetic grass.

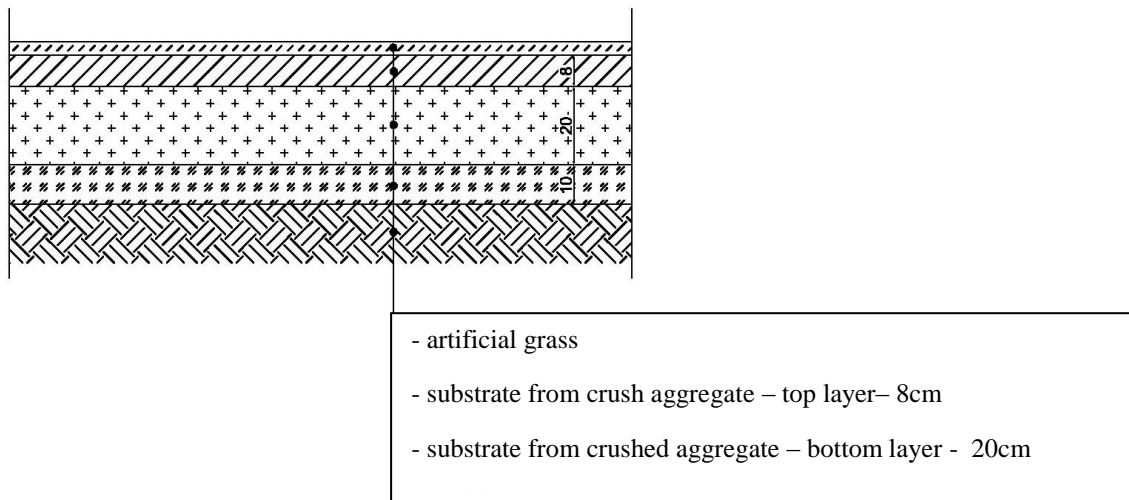


Fig.2. Construction of synthetic grass surface; Source: prepared by the authors based on [1, 2, 3, 10].

Fibres are made from polyethylene or polypropylene. Polyethylene fibres are less rough and more delicate, which reduces the risk of skin abrasion when a player falls down. Moreover, polyethylene is more resistant to wear, UV radiation and minus temperatures than polypropylene fibers. Polyethylene grass is recommended for sports with a higher risk of falling down, e.g. football. Substances used as infill in artificial grass are quartz sand and SBR or EPDM granulate. Quartz sand makes the surface adhere to the substrate and minimizes the trampling of grass. The granulates provide right ball-bouncing capacity and ensure that any fall of a player will be less rough. EPDM is considered to be the most durable granulate; it is also more fire resistant and, most importantly, less vulnerable to compaction. On the other hand, an undisputable advantage of SBR is its price.

Although artificial turf does not have to be mowed or watered, some form of regular maintenance, including removal of any debris from its surface, is just as important. It is also necessary to regularly check and repair any damages, such as holes, undone lines of binding between grass rolls or along the sides of a pitch, etc. Artificial grass also needs periodic combing to fluff the fiber blades, loosen the infill granulate and remove moss or weeds which can grow in the granulate layer (all maintenance treatments should be carried out as often as needed depending on how much the surface is used). It is also important to provide and maintain the water permeability of the pitch by perforating the upper layer of artificial grass surface. Maintenance treatments on artificial grass surface should be performed at least twice a year. Possible repairs include renovation of some worn or damaged parts of the turf, which will help to avoid replacing the whole surface. When mechanical damage is found out, then the damaged fragment of grass surface must be replaced.

POLYURETHANE SPORT SURFACES

Most professional sport surfaces are made from polyurethane. With PU surfaces, it is possible to create attractive sporting grounds, but also ensure safe conditions for practicing sports by helping to protect joints, bones and particular parts of the body. PU surface is the best type of surface to finish multi-purpose sporting grounds, also the ones dedicated to children or to professional athletes. PU surfaces are installed in professional athletic stadiums,

school racing tracks and multi-purpose sporting grounds. They are made from high quality polyurethane components and rubber granulates. PU surfaces can be used in indoor and outdoor facilities. The seamless uniform polyurethane surface, achieved with the state-of-the-art technology, is resistant to wear and microbial damage. The main advantage of PU surfaces is their bounciness and elasticity, which ensures much safety and comfort of use. Polyurethane surface is made directly on a construction site and laid on specially prepared base. It does not require complicated care treatments, which is why maintenance costs are very low. PU surface can be spray-applied or paved, with specially designed machines used for construction of professional sports facilities. Polyurethane surfaces made from rubber granulate can be used on courts for playing tennis, volleyball, handball and basketball. There are also racing tracks, run-ups for long and high jump, playgrounds and multi-purpose sporting grounds with PU surfaces. The universal character of this solution arises from the seamless structure, water permeability, UV radiation resistance, high elasticity (minimizing the risk of injuries), very good ball bounciness and resistance to atmospheric conditions. PU surfaces need little maintenance care.

Depending on the designed use, polyurethane surfaces can be 13-35 mm thick and may be characterized by a different degree of permeability and elasticity, which for example depends on the type of substructure. If a PU surface is laid on a base made from crushed aggregate, then a stabilizing base ET layer has to be made underneath the proper PU surface. This subsurface layer is composed of rubber granules, polyurethane binder and quartz aggregate. Polyurethane surfaces are available in a wide range of colours, of which brick red and green are the most popular and practical ones. In our further discussion, we will deal with permeable polyurethane surface on crushed aggregate base, as seen in fig. 3.

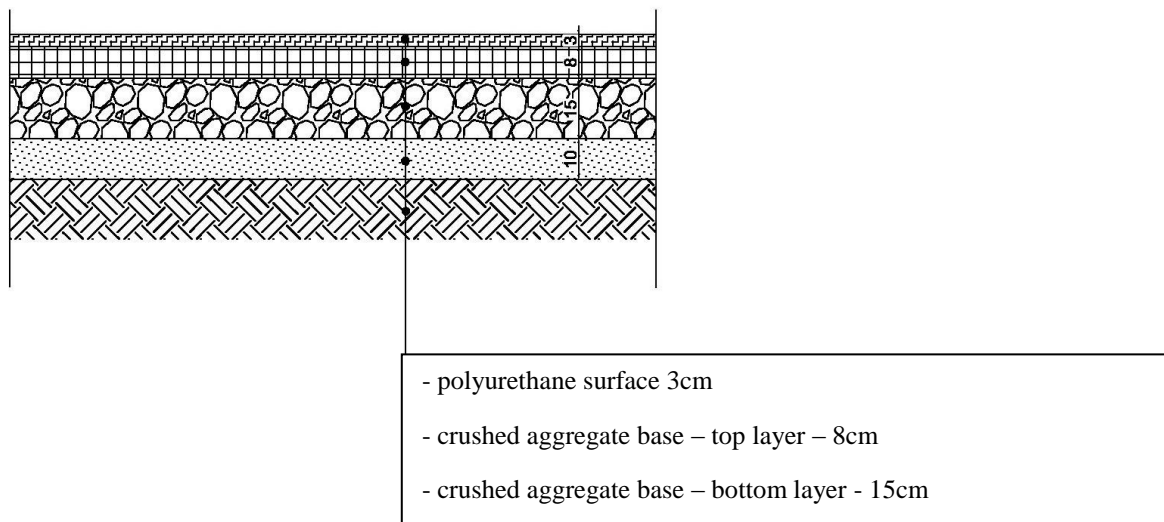


Fig.3. Construction of polyurethane surface; Source: prepared by the authors based on [1, 2, 3, 10].

To keep polyurethane surface in good condition, between seasonal maintenance treatments, the ongoing care involves removing litter and debris (e.g. using industrial vacuum cleaners or air blowers) and inspecting the surface to spot and immediately repair any damage. The surface should be regularly washed to remove dust and dirt, using pressurized water (the frequency of this treatment depends on how intensively the surface is used). Any contamination with oils, lubricants or paints must be removed as quickly as possible, with suitable chemical preparations which will not react with the given surface. It is recommended to carry

out at least 2 or 3 times a year a complex maintenance and conservation treatment, that is to wash the surface with chemical preparation, using special high-pressure washing equipment or scrubber driers (deep cleaning). When some damage or hole is noticed in PU surface, it must be immediately repaired to avoid further devastation.

ACRYLIC SURFACES

Acrylic surfaces are made from high quality synthetic resins, which produce seamless surface, perfect for both outdoor and indoor facilities, for tennis courts, multi-purpose sports grounds, skate parks, roller skating tracks and playgrounds. The advantages include: safety for users, resistance to wear, good adhesion, elasticity and finally a relatively low cost of installation, which makes acrylic surfaces popular and accessible. Acrylic surface is produced layer after layer, manually, at a construction site, using purpose-design tools. It must be made on a perfectly flat asphalt and concrete or concrete base. Among its disadvantages the following are mentioned: low resistance to damage, strikes and wear. Such advantages as seamless surface, very good ball bounce, resistance to weather conditions, no reflection of light or sunlight and multi-purpose use make acrylic surfaces suitable in different facilities.

A field with acrylic surface does not need any special maintenance. It is enough to respect basic sanitary rules (remove dust and dirt) to fully enjoy it.

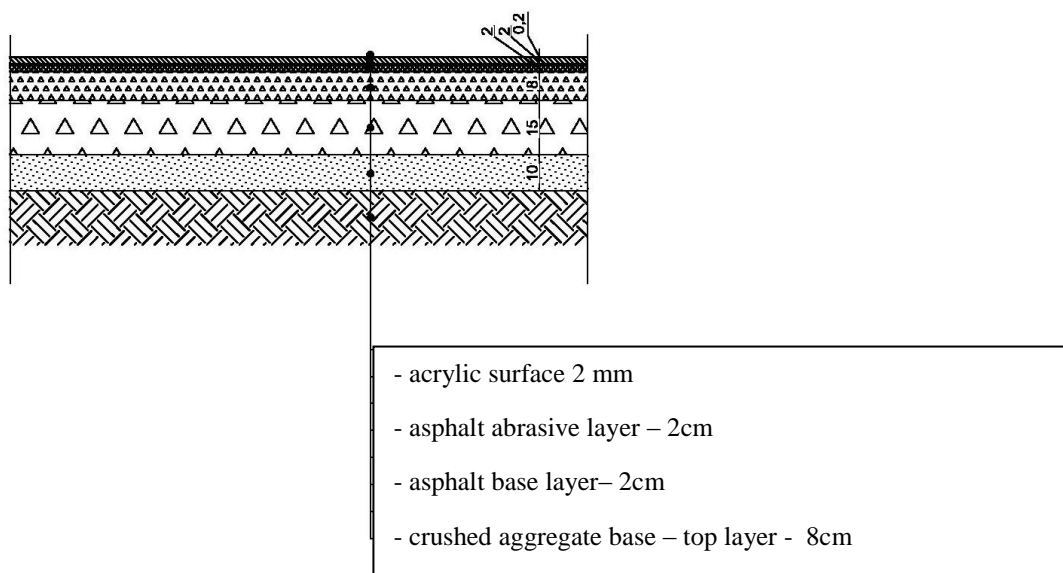


Fig.4. Construction of acrylic surface; Source: prepared by the authors based on [1, 2, 3].

ANALYSIS OF INSTALLATION COSTS

The costs of building the above surfaces are different, basically because of the different materials and technologies used for their manufacture and installation. Our analysis was based on a costs estimate performed with the aid of the NORMA PRO software, educational version. The annual maintenance costs for the analyzed types of sporting ground surfaces were found in brochures published by companies which make and maintain such surfaces. Having recalculated the above costs per 1 m², we obtained the specification of costs as presented in table 1.

COMPARISON OF SPORT GROUNDS SURFACES

When making a comparison of surfaces used sports facilities, different aspects should be taken into consideration. Different solutions have different applications and are suitable for different sports and facilities. Costs must be analyzed in a broader perspective, that is the costs of erecting a given building or object should be seen in relation to the planned life of the

construction. As seen in the juxtaposition present in the table 1, the least expensive solution is natural grass surface, but when a 15-year life of the surface is taken into account then we will see that natural grass is not the best option. In addition, the natural turf can be used for no more than 5-6 hours a week, which again makes this otherwise popular and inexpensive solution less attractive.

Table 1. Specification of costs of installation and maintenance of different types of sports surfaces

No	Type of surface	Cost of building the surface in PLN/m2	Annual maintenance costs in PLN /m2	Costs of building and using for five years	Costs of building and using for 15 years
1.	Natural rolled grass	74.15	3.5 – 4.3 (on average 3.9)	93.65	132.65
2.	Artificial grass	106.26	0.21 – 0.43 (on average 0.32)	107.86	111.06
3.	Polyurethane surface	133.69	1.2 -1.4 (on average 1.3)	140.19	153.19
4.	Acrylic surface	95.94	does not apply	95.94	95.94

Source: prepared by the authors based on [8].

Table 2. Specification of basic parameters of the analyzed surfaces.

Property of the surface	Natural grass surface	Synthetic grass surface	Polyurethane surface	Acrylic surface
Substructure	- gravel and sand - fertile soil	- crushed aggregate - concrete, - asphalt and concrete	- asphalt and concrete - pervious concrete, - polyurethane base - rock aggregates	- asphalt and concrete with smooth surface - crushed aggregate, concrete,
Water permeability	Permeable	Permeable	Permeability depends on the type of substructure	Waterproof
Maintenance	Needs constant and time consuming maintenance	Needs maintenance	Needs maintenance	Does not need maintenance
Construction technology	Simple to make, few layers, but takes time for grass to root and grow strong	Simple to make, few layers	Needs several layers to make and a suitable base	Complex process to make, many layers and great precision needed .
Advantages	- natural surface, - permeable, - easy to make	- permeable, easy to make, no time limits to use	- high safety for players' bones and joints, - very elastic, - resistant to UV radiation, - very good ball bounce, - high costs of making	- very good ball bounce, - does not reflect light or sun rays, - a wide range of colors, - does not need much maintenance, - low costs of making
Disadvantages	- limited time to use non-stop, - needs maintenance and care	- not very resistant to UV radiation, - needs maintenance	- high costs of making, need maintenance	- needs a smooth, even base, with closed structure

Source: prepared by the authors

Many owners and managers of sports facilities believe that artificial grass is a much better solution, which is aesthetically as pleasing as real grass.

It is slightly more expensive to install, but considering a longer usable life of synthetic grass surface, the above difference is offset by much lower maintenance costs. Besides, there is no limits as to how long artificial grass surface can be used daily or weekly. The most modern solutions are polyurethane and acrylic surfaces. Acrylic surfaces are less expensive to install and have an additional advantage such as the possibility to use them for many years without any special maintenance treatment. On the other hand, they are less versatile in use than PU surfaces and their installation is much more difficult. The base under a 20mm layer of acrylic surface must be very well prepared to be perfectly even and smooth. In table 2 you will find the specification of basic parameters of the analyzed surfaces.

SUMMARY

Surfaces of stadiums, pitches, running tracks or tennis courts can have different structures and surfaces. They can be used for many years provided a suitable surface is made. Our comparison of the most popular types of surfaces does not give an easy answer to the question which of the analyzed solutions is the best. The four compared solutions are different in the substructure and maintenance; some of the technologies employed to make them can be more complicated than the others. Tables 1 and 2 help to compare costs of making and keeping the four types of surfaces as well as some of their technical properties, which make the given surfaces more suitable for certain types of sports and sporting grounds. The costs analysis showed that the costs of making specific surface are not sufficient for making an investment decision. Equally important is the cost of future maintenance of the planned building or object, which is often a decisive factor in estimating the final profitability of the whole enterprise.

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