RESEARCH ARTICLE

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Renovation of natural grass football fields using carpet-based hybrid method: The case of Atatürk Olympic Stadium

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Abstract
Since the playability and performance of hybrid turf pitches reflect natural grass pitch standards, they have been used in Europe for more than 20 years and have been frequently preferred in Turkey recently. Although hybrid turf systems are installed on football fields by various methods, the most popular one is the carpet-based hybrid method. These types of fields can be built from scratch or by renewing natural grass fields. When renovating natural grass fields, it should be considered that the processes and applications have a complex structure and the works should be carried out within a certain system. In this study, the renovation of the playing surface of the Atatürk Olympic Stadium, which is expected to host the UEFA Champions League Final in 2020, from natural grass to carpet-based hybrid grass has been examined. All renovation works were meticulously observed on site and the experiences gained were tried to be conveyed. In this way, it is aimed that the study will serve as a guide for future renovation work. Due to the complex nature of the renovation process, it is important to have the necessary knowledge when carrying out these operations. Since the renovation of these areas is expensive, it is important to ensure the necessary conditions are provided. The correct materials, essential technical equipment, and skilled personnel must be provided for the operations to be carried out, and measures must be taken to prevent any potential problems that may arise during the renovation phase.
Keywords: Atatürk Olympic Stadium, Football pitches, Hybrid grass, Renovation

INTRODUCTION

Football, which is extremely popular in Turkey, is the most popular sport worldwide (Hocaoglu & Bingol, 2022). It is played on every continent, in every country, and on many different levels (IFAB, 2021). Compliance of the football field surface with standards is key for both football players and spectators. The playing surfaces must comply with these standards in terms of functionality and broadcasting corporation visuals (Bingol, 2004).

The surface of football fields on which competitions are held can be completely natural or composed of a combination of natural and artificial materials (also known as the hybrid system), which is allowed for competitions; in some cases, the surface is allowed to be completely artificial (IFAB, 2021; Hocaoglu & Bingol, 2022).

According to the International Football Association Board's (IFAB) Dictionary of Football Terms (2018), the hybrid system is defined as 'a combination of artificial and natural materials to create a playing surface that requires sunlight, water,

air circulation and mowing' (IFAB, 2018). In the Union of European Football Associations's (UEFA) Field Quality Guide (2018), hybrid systems are mentioned in the 'Turf Support/Reinforcement Systems' section (UEFA, 2018), where they are described as 'attempts to combine the benefits of natural grass in terms of playing quality with the practical reinforcing and engineering advantages of artificial materials' (UEFA, 2018). In summary, a hybrid turf is a product composed of both natural and artificial turf that strengthens natural turf, increases its durability, and ensures its green appearance throughout the year (Hocaoglu & Bingol, 2022).

Hybrid grasses can be prepared via different methods, including the carpet-based hybrid method. This method can be applied in a new field facility as well as in an existing field after the soil surface is removed and subsoil is prepared and levelled. In addition, the carpet-based method can be used on sod farms, where thick and long rolls of grass carpets can be placed in the field (lay and play) (Hocaoglu & Bingol, 2022). Polypropylene synthetic material is placed on a specific backing material that is partially biodegradable and developed to ensure the deep and rooted growth of natural grass via knitting or weaving. This backing is in the base cloth (pad/cotton fibre/polypropylene) and appears in the form of a grid. The grid material and the base cloth are knitted together. Furthermore, this backing allows an easy and high-quality installation. Biodegradable fibres completely degrade within two months, thus creating a matrix of large uniform spaces through which plant roots can grow at locations where moisture and nutrients flow (Hocaoglu & Bingol, 2022; *Hybrid Turf System*, 2022).

Carpet-based hybrid systems offer several benefits. By providing permeability and oxygen flow to the surface layer, it provides the optimum conditions for natural grass and creates an ideal air–water soil balance. This increases the reliability of the field in terms of evenness and stability in areas with significant game traffic; furthermore, owing to the strong grass structure afforded, deep gaps do not occur. The carpet base, which serves as a geotextile, prevents the formation of deep crampon divots during undesirable weather conditions and heavy use, provides rapid regeneration in the lower root zone layer, and protects the grass root system. Furthermore, it improves the aesthetics of the field with its green appearance of synthetic fibers (Hocaoglu & Bingol, 2022).

The transformation of the Atatürk Olympic Stadium from a natural grass field to a carpet-based hybrid system is discussed and analyzed herein. This study may serve as a reference for similar renovations in the future.

MATERIALS AND METHODS

The main focus of this study is the 2019 renovation of the playing field at the Atatürk Olympic Stadium. The construction of this stadium began in 1998 and was completed in 2002, with natural grass used for the match field. The stadium was scheduled to host the UEFA Champions League Final in 2020, and renovation began before the event. During the renovation, the existing athletics track was removed, elevations were rearranged, and the natural grass field was converted to a hybrid carpet-based system. However, despite these renovation efforts, the UEFA decided to switch the competition venue from Istanbul to Lisbon because of the COVID-19 pandemic.

Material

The Atatürk Olympic Stadium, which is the area investigated in this study, is located in the Başakşehir District of Istanbul, Turkey (Figure 1). The facility, named after the country's founder Mustafa Kemal Atatürk, is the largest stadium in Turkey in terms. The stadium was built for Turkish athletes and football as preparation for the Olympic Games (*Atatürk Olimpiyat Stadyumu*, 2022).

The Atatürk Olympic Stadium, which opened on 31 July 2002 with a match between Galatasaray and Olympiacos attended by 77,087 people, is a stadium that satisfies the requirements of the International Association of Athletics Federations (IAAF), the Fédération Internationale de Football Association (FIFA), and the International Olympic Committee (IOC) for international football and world athletics championships.

The infrastructure of the stadium not only facilitates sports, social, and cultural activities, but also enables the training of athletes, coaches, and trainers. The Atatürk Olympic Stadium comprises two illuminated training

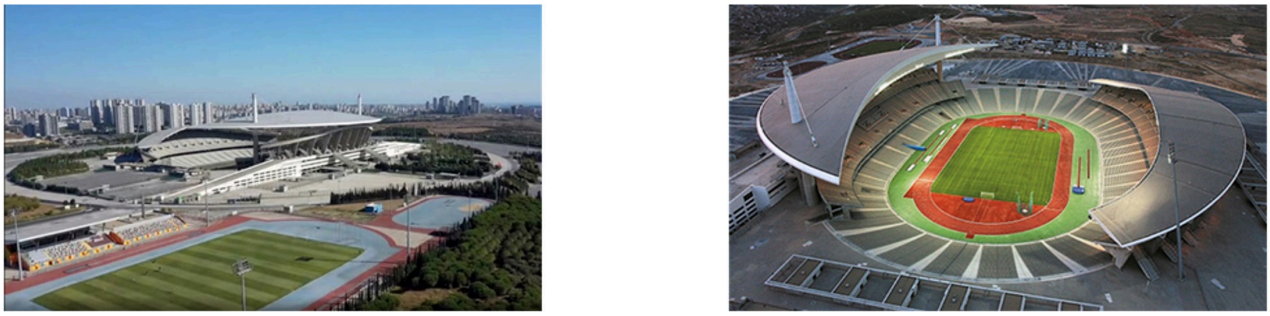

Figure 1. The Atatürk Olympic Stadium general appearance (*Atatürk Olimpiyat Stadı*, 2022; *Istanbul Atatürk Olimpiyat Stadyumu,* 2022)

and athletic fields (*Stadyum*, 2022) and is one of the few stadiums worldwide that has hosted large organizations (*Atatürk Olimpiyat Stadyumu*, 2022).

Method

During the renovation of the Atatürk Olympic Stadium, the athletics track was removed and replaced with tarmac, and the levels on the sides of the field were reduced by 90 centimeter. Additionally, the natural grass surface of the Atatürk Olympic Stadium was replaced with a carpet-based hybrid system. For a carpet-based hybrid system, a coverage distribution of 95% natural grass and 5% synthetic fibre is desired. The hybrid turf to be used depends on the carpet weight or filament density. Hatko Hybridgrass 55DS10, which contained 66,000 filaments per square meter, was used in the Atatürk Olympic Stadium. The material comprises a patented base cloth with more than 50% gap, thus allowing it to pass through high-quality OMEGA fibres after the germination of the seed's roots.

During the transformation to the carpet-based hybrid system, 10 centimeter of stripping (on average) was performed on the existing natural grass surface area to comply with the specifications, and the plant growth medium was renewed. After installing the carpet-based hybrid system, the filling was laid. The renovation was completed after the sowing of grass seeds.

On-site observations were performed during the renovation. The carpet-based hybrid system was examined based on six main criteria, and the renovation process is explained comprehensively herein. This study may serve as a reference for similar renovations in the future. The data and findings obtained during the renovation process were evaluated to provide suggestions for future renovations.

RESULTS AND DISCUSSION

The ground renovations completed at the Atatürk Olympic Stadium were as follows:

- Stripping of the athletics track and adjustment of the levels
- Preparation of the lower root zone of a carpet-based hybrid system
- Installation of a carpet-based 'hybrid carpet'
- Infilling of the upper root zone
- Sowing of grass seed
- Finishing works

Stripping of the athletics track and adjustment of the levels

According to the criterion stipulated by the UEFA, a stadium hosting the Champions League Final must have a seating capacity of 70,000 people with a full view of the stadium. Because of this requirement, the athletic track of the Atatürk Olympic Stadium was removed and then paved with asphalt during the renovation, and the elevation on the sides of the pitch was reduced by 90 centimeter to improve the view from seats with an unsatisfactory view (Figure 2).

Consequently, the seating capacity was 74,753, which satisfies the UEFA criteria. Furthermore, 250 of these seats were reserved for disabled spectators (*Atatürk Olimpiyat Stadı, Avrupa'yı kucaklamaya hazır*, 2020).

Preparation of the lower root zone of a carpet-based hybrid

In the field renovation, the existing natural grass surface was first removed. Fraise mowing was performed on the ground using a dedicated machinery to strip the natural grass surface (Figure 3). The existing plants and root zones were completely removed from the surface.

Subsequently, the existing infrastructure system in the field was inspected for any damage or deficiencies, which are to be eliminated. During this inspection, no renovations were performed on the infrastructure. A new root zone was established using a top dressing. At this stage, the ground was prepared for the carpet-based hybrid system by compacting and readjusting the ground levels (Figure 4). Subsequently, the levels were reverified to prevent undulation.

During the levelling, the undulating values in the longitudinal and lateral directions between 3 meter straight edge beams with 3 meter intervals were targeted to be less than 10 millimeter. Soil stability was measured using a penetrometer that can measure more than 1.5

Figure 2. Removing the athletic track and paving with asphalt (*Atatürk Olimpiyat Stadı'nın son hali*, 2020; *İstanbul Atatürk Olimpiyat Stadı Yenileme Projesi*, 2019)

Figure 3. Removing The Existing Natural Grass Surface (*Hatko Sport*, 2019)

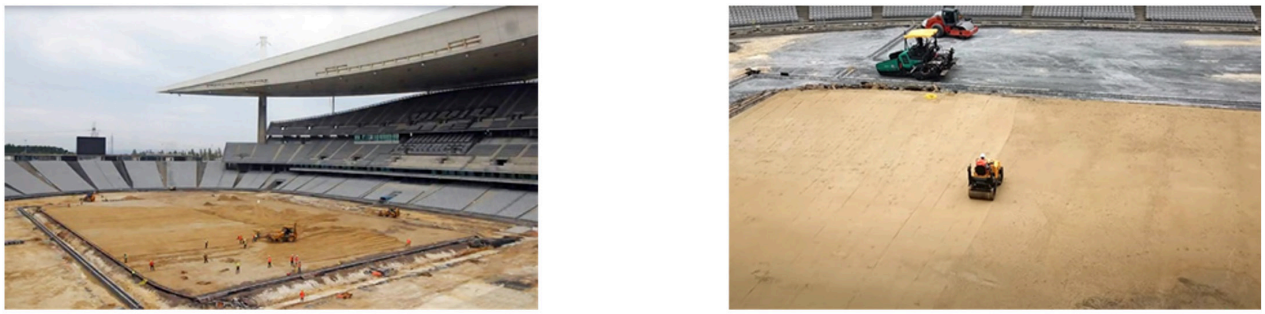

Figure 4. Establishment of the new root zone (*Hatko Sport*, 2019)

Figure 5. The process of laying the carpet-based 'hybrid carpet'

N/mm^2 (cone size = 1 cm^2). The irrigation springs in the infrastructure system were adjusted to 20 millimeter above the level of the completed lower root zone.

Installation of carpet-based 'hybrid carpet'

Before installing a carpet-based 'hybrid carpet,' the ground where the hybrid grass with a carpet base was laid, in which the lower root zone was prepared, was re-inspected for inaccurate field levels. During the laying process, 4 meter carpet-based hybrid grass rolls were laid on a field using a pedestrian-type self-propelled equipment.

Additionally, the corner points of the carpet-based hybrid area were determined. In the area where the carpet was to be laid, a stake was placed at each corner, which resulted in an excess of 15 centimeter on all edges, and a yellow or white string line was placed between each stake. The first roll was laid by moving it to one side such that it coincided with the string line marking the outer edge of the carpet at +15 centimeter. The hybrid carpet was laid meticulously such that it was stretched in both longitudinal and lateral directions.

The rolls were folded from 40 centimeter on the side where the first roll (and each subsequent roll) was installed and cut cleanly from the excess backing until the first tuft line without requiring the stitching of artificial fibres. This strip of clear backing served as the carrier tape for the carpet adhesive. A second roll was unrolled, and the carpet was positioned manually such that the outer tuft line was shielded by the previously cleared adhesive carrier strip (Figure 5).

The carpet was manually folded from 40 centimeter on the side where the first roll (and each following roll) was installed and cut cleanly from the excess backing until the first tuft line without requiring the stitching of artificial fibres. This strip of clear backing served as the carrier tape for the carpet adhesive.

A PU carpet adhesive was prepared for bonding the rolls. The adhesive, which was mixed slowly in a tube,

Figure 6. a) Application of the adhesive b) Bonding the rolls

was transferred to a glue gun for use (Figure 6a). The adhesive was applied to the carrier strip using a glue gun. The viscosity of an adhesive depends on the environmental temperature; therefore, an appropriate amount of adhesive must be used. Depending on the weather conditions, the adhesive and its carrier edge strip may require water spray to improve the hardening of the adhesive.

The adhesive-applied carpet was carefully unrolled and transferred onto the adhesive such that the fibre-woven strips matched perfectly with the other carpet (Figure 6b). After sealing the seam, rolling was performed using a specific hybrid turf carpet roller (HCR).

The timing and intensity of the rolling process of the adhesive-applied joints of the hybrid carpet were adjusted based on the weather conditions. After the carpets were adhered together, the adhesive was inspected every 10 minute by slightly lifting the edge of the upper carpet. After ensuring that the upper carpet did not adhere to the carrier strip, the rolling process was commenced. The seam was rolled twice at a moderate speed while ensuring that no wrinkles were visible in front of the HCR.

A sufficient hardening duration (6–12 h) was allowed before the carpet was infilled. The joints were re-inspected, and any loose joints detected were repaired using HATKO repair glue. These steps were repeated until the entire area was shielded with a carpet-based hybrid turf. A total of 5 day was required to lay the carpet-based hybrid system.

The root zone was filled after the bonding process was completed and the entire hybrid carpet was transformed into a single piece. However, a preliminary preparation was performed to ensure that the carpet and alignment would not slip and that the surface would not wrinkle/fold/undulate during the filling process. Based on the outer perimeter of the carpet-laid area, the hybrid grass carpet was folded back by 1 meter. A shallow channel (100 mm wide and 150 mm deep) was created on one goal side (short side) and one longitudinal side (long side) of the pitch. A trench was created along the inside of the string line, and the excavated material was uniformly preserved outside the string line. The folded carpet was opened, placed in the duct, and backfilled next to the trench using the preserved material. The trench was compacted using a tractor tire (a tractor with a turf-type tire), and the soil was relevelled without allowing undulations and/or damage to the elevations.

Infilling of the root zone

The preparation for the upper root zone involved filling the football field with carpet-based hybrid turf rolls. Prior to performing the topdressing process, the material to be used was stored on a clean surface to ensure dryness.

During the renovation of the field, a time-efficient spinner-type top-dressed equipment with an adjustable spreading width (3.5–13 m) was used to perform infilling (Figure 7a). A load weight not exceeding 1,500 kilogram was used to avoid damage to the field surface during topdressing. In addition, tractors, which were used to protect the surface, were equipped with weight-distributing turf-type tires. In the backfilling process, sand was dispersed on the field in layers with a maximum thickness of 6 millimeter.

Figure 7. (a) Topdressing process (b) Brushing and levelling with drag-mat

Figure 8. (a) Raking the field (b) Pumice application

Any loose material remaining on the surface after topdressing with the sand was cleaned by brushing, and the distribution of sand on the surface was ensured to be homogeneous using a levelling mat (Figure 7b). Consequently, the synthetic fibres in the hybrid system remained upright, and the buried fibres reached the surface. During this process, the longitudinal fibres of the carpet were brushed in the opposite direction. These processes were repeated until the filling reached a loose depth of 35 millimeter (32 mm compressed).

Additionally, the irrigation is to be considered during the laying and filling processes. To avoid the loss of springs in the irrigation system, a mark was created on the carpet at a distance of approximately 100 millimeter from the centre of the springs, and the hybrid grass carpet was folded down to reveal the springs. These points were marked with a flag and inspected by an irrigation manager to ensure that no springs were overlooked.

One of the main concerns pertaining to hybrid-system football fields is the formation of organic materials. Organic materials typically grow on the fibres, causing the latter to be embedded below the surface. After performing scanning, all organic residue accumulated on the field surface was cleaned, and synthetic fibres embedded in the organic layer were removed and rendered vertical (Bingol & Hocaoglu, 2022).

During the renovation, the field was groomed using spring-loaded rakes. The field was regularly raked up to the root zone surface. Consequently, the formation of organic materials was prevented, and any embedded synthetic fibres were removed and rendered vertical (Figure 8a).

During topdressing with sand, pumice was added to the mixture and applied to the area to maintain the strengthened ground and to improve its water-retention ability (Figure 8b).

Sowing of the turf seed

Football fields with hybrid systems are sowed the most effectively using 'dimple seeder' equipment with wide castings. Because field seeding can cut or destroy synthetic fibres, cutter/disc seeding equipment should not be used to prolong the life and efficiency of the fibres (Bingol & Hocaoglu, 2022).

Hence, during the renovation, a poking cylinder-type seeding (dimple seeder) equipment was used to sow grass seeds in the field (Figure 9). For seed planting, a grass seed mixture comprising 80% Lollium prenne and 20% Poa pratensis is desirable for the regional climate. A 22+05+06+2Mgo+Te fertilizer was used during seed sowing. Irrigation was initiated after seeding.

Finishing works

Finishing works were performed to develop the playing field, which resulted in form and maintenance phases. A pedestrian-type cylinder mowing equipment was used for mowing (Figure 10a). This is because heavy mowing equipment causes the fibres in the hybrid system to break and fold flat.

Performing daily mowing using a pedestrian-type cylinder mowing equipment weighing less than 200 kilogram reduces the risk of fibres folding in the hybrid system (Bingol & Hocaoglu, 2022). The preferred mowing height in the football field was 25–30 millimeter. To ease

Figure 9. Sowing of the turf seed


Figure 10. (a) Mowing the grass (b) Final appearance of the field (*Atatürk Olimpiyat Stadı'nın son hali*, 2020)

the management of the football game and create an aesthetically pleasing stadium, shaping was performed in opposite directions to form parallel patterns (Bingol & Hocaoglu, 2022).

Maintenance practices were commenced after the renovation was completed. An image of the completed stadium is shown in Figure 10b.

CONCLUSIONS

Reinforced turf establishment methods (hybrid turf) are typically preferred for the construction of football fields in Turkey, similar to the worldwide preference. The pitch required can be created or easily obtained by renewing natural grass-surfaced pitches. Herein, the renovation processes performed on the grounds of the Atatürk Olympic Stadium, which was expected to host the UEFA Champions League Final in 2020, was discussed. The most important processes were the removal of the existing natural grass surface and the application of the carpet-based hybrid system to the area.

The following aspects are noteworthy during the processes:

- The stripping process must be performed by experts, and the infrastructure system in the area should not be damaged.
- After top dressing with sand, field elevations should be inspected, and uneven levels should be prevented.
- Carpet-based hybrid grass rolls must be laid meticulously to ensure that they are tight and taut.
- The bonding of the rolls should be performed meticulously, and any loose joints must be identified and tightened.
- After laying the rolls, sandblasting should be performed using an appropriate distribution of sand.
- The material remaining on the surface should be cleaned by brushing, and a homogeneous distribution of sand should be ensured using a drag mat.
- During the laying process, the irrigation system should be monitored, and spring loss must be prevented by adopting the necessary precautions.
- Embedded synthetic fibres should be removed via raking and rendered vertical.
- Cylinder-type seeding (dimple seeder) equipment should be used for sowing grass seeds, and grass seed species suitable for the regional climate should be selected for seeding.
- Pedestrian-type rotary mowers or cylinder mowers are preferred for mowing.

Because carpet-based hybrid turf pitches exhibit a more complex structure than natural grass pitches, the renovation processes must be performed within a certain retrospective control system. An appropriate number of personnel must be trained to renew natural grass surface areas using a carpet-based hybrid system. Necessary equipment should be provided to ensure a well-functioning and problem-free field. The appropriate regeneration processes will contribute to the sustainability of the field, visual aesthetics, game quality, and health conditions of athletes.

COMPLIANCE WITH ETHICAL STANDARDS

This research article complies with research and publishing ethics.

Peer-review

Externally peer-reviewed.

Conflict of interest

The authors declare that they have no competing, actual, potential or perceived conflict of interest.

Author contribution

The contribution of the authors to the present study is equal. All the authors read and approved the final manuscript. All the authors verify that the text, figures, and tables are original and that they have not been published before.

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Data availability

Not applicable.

Consent to participate

Not applicable.

Consent for publication

Not applicable.

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