Artificial Turf **Gains Ground** with Realistic Simulation

The Fédération Internationale de Football Association (FIFA) has deemed artificial turf "an acceptable playing surface for football." The association cites the availability of an evergreen, even-playing surface as advantages of artificial turf over natural grass. But FIFA has also spelled out detailed regulations about the materials, substructure, installation, testing, and certification of artificial turf for playing fields—which means that turf manufacturers have to be on the top of their game when designing their products for performance and safety.

Royal TenCate (pronounced "ten-kah-teh") is the world's leading producer of synthetic grass fibers and other components for playing fields. Whether the game is soccer, American football, rugby, field hockey, or lacrosse, a playing field must be able to take a significant amount of pounding from feet, sports balls, and falling bodies. Add different climates (hot versus cold, wet versus dry) and impact patterns (heavily padded American football teams versus bare-kneed soccer players) and you begin to get an idea of the design variables that TenCate must take into account when designing artificial turf.

Synthetic Turf: More Than Meets the Eye

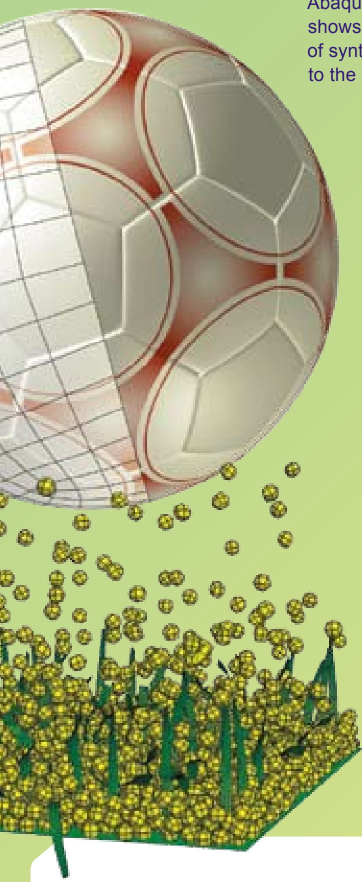
Artificial turf designers must consider the make-up of the individual blades to mimic the look and playing-feel of natural grass. They must consider what yarn/fiber to use (softer polyethylene for soccer, tougher polyamides for U.S. football), what shape it should be, whether it should be fibrillated or a monofilament, its height above the field surface, its density per square meter, stiffness and dissipative behavior—all of which affect wear, safety, and playing characteristics.

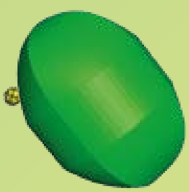
Synthetic turf is actually a complete system of grass fiber, infill and backing, laid over a foundation of earth, sand and/or concrete. Components are fine-tuned to the environmental conditions where a field is being installed.

However, what's below the visible surface of the grass is just as critical: the fiber travels down through infill made of rubber or thermoplastic granulate, which provides shock absorption, controls rebound and prevents skin damage caused by sliding. Beneath that are additional layers of rubber and sand and, finally, the backing in which the grass blade (totaling 6 cm in length) is imbedded.

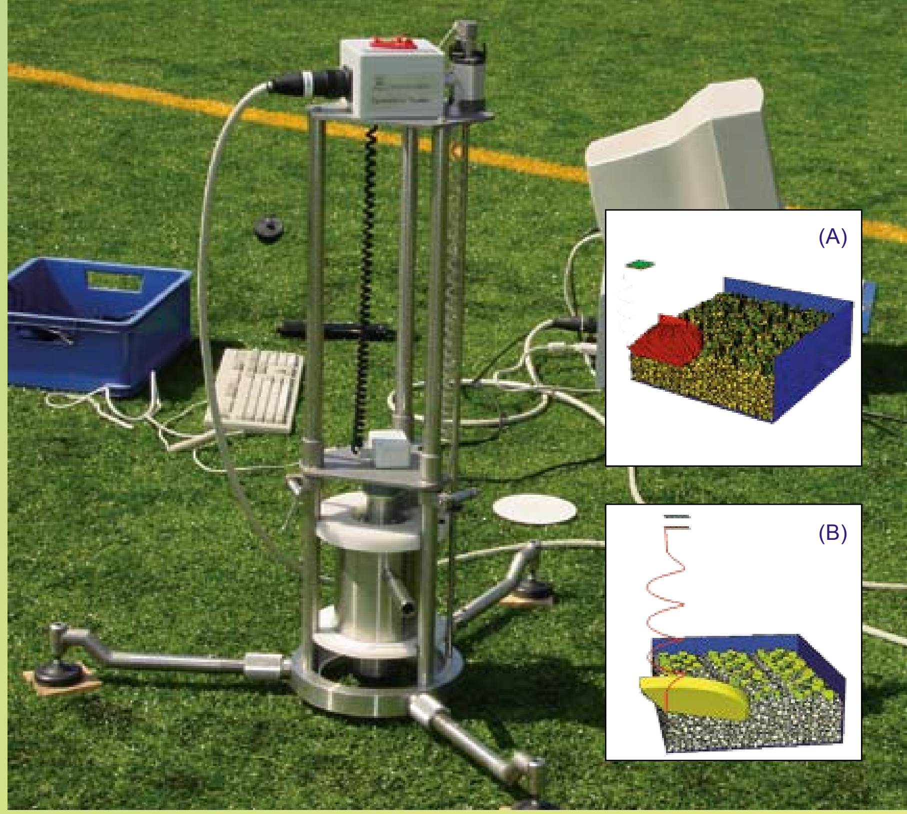
"For optimum performance you need to fine-tune all the elements that make up a field," says Martin Olde Weghuis, International Manager, R&D, at TenCate. "We make distinct types of polyethylene grass fibers, plus thermoplastic infill material, and polypropylene woven backing fabrics—all of which must work together for optimum results."

Marco Ezendam, Director of Reden BV (Research Development Nederland), engineering consultants to TenCate, explains, Abaqus FEA ball-bounce model shows interaction and response of synthetic turf infill and fibers to the impact of a soccer ball.





FEA model of individual granule



The Abaqus FEA data from fiber and infill testing is combined into field properties models with which load (A) and displacement (B) effects can be simulated. Field testing using the “artificial athlete” (photo) verifies the results predicted by the model.

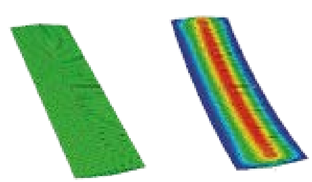
“A playing field is an entire system, not just individual components. If you want better performance from the field, you have to know how the entire system functions and what the interactions are within it. That’s the reason we started modeling turf design with Abaqus finite element analysis (FEA).”

“We initially chose Abaqus because of the breadth of its materials models,” Ezendam says. “The capabilities of the software have grown along with our need for increased sophistication in our analyses. With Abaqus FEA you can model the individual characteristics of each component and relate that to the behavior of the total system.”

Modeling the Playing Field

When creating artificial turf models, Reden looks at the problem at a number of levels: micro, the properties of an individual fiber; meso, grains of infill interacting with fibers; and macro, a ball or player impacting the field. “We use FEA to model the properties of a single fiber, translate those into the properties of a group of fibers, and then predict the characteristics of the mass, spring and damping of the field itself interacting with a ball or player,” says Ezendam.

A grass-fiber model in Abaqus can be subjected to virtual bending tests, and its mass, shape, height, etc. modified and retested, until the desired characteristics are achieved. Infill models can be adjusted for morphology, size, material, distribution, friction and layer thickness, and then run through triaxial (three-dimensional) compression tests. An entire square of turf, with fibers, infill and backing characteristics built into the model, can be evaluated for compression by a virtual foot or a bouncing ball.



Reden’s modelling strategy for TenCate’s artificial turf starts on a micro level with Abaqus FEA analysis of an individual synthetic fiber, shown here. Mass, shape, bendability, height and other characteristics can be modified and retested until the desired requirements are met.

By using FEA during product development, Reden can also simulate the effects of the artificial athlete tests on their turf models. The foot simulation mirrors a real-world test, mandated by FIFA. It consists of a circular plate, approximating a player’s foot, that is pressed onto the field with a loaded spring to measure field behavior. Reden uses two artificial athletes: the Berlin tests the maximum load on the plate and the Stuttgart measures displacement of the plate. The physical tests are performed on the synthetic turf at TenCate’s outdoor testing fields. They then use the simulations to evaluate the performance of different combinations of turf fiber, infill and backing, and make modifications that will optimize the turf’s performance in the outdoor tests.

In a similar manner, a ball-bounce analysis is set up using an FEA shell model of a ball full of gas at the correct pressure. For comparison, a real ball is bounced off a surface and the rebound results are then factored into the simulation of the synthetic turf response and used to make product modifications as needed.

FEA Measures Up

With its computer models set up, Reden turns to validation testing against the FIFA-mandated parameters that must be met by every synthetic field. While a single turf-fiber model is fairly simple to build, a full model of a simulated foot impacting a section of turf can have over 250,000 elements with over two million degrees of freedom.

“We are now at the point of validating all our models, and the graphs of our real-world results against what our FEA models predict are coming out very strong,” concludes Ezendam.

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