This case study describes the installation and performance of a third generation artificial football pitch at Woodley Sports FC, near Stockport. The ‘turf’ comprises plastic carpet in-filled with a mix of sand and recycled rubber cryogenically derived from around 150 tonnes of used car tyres.
Key facts

- ‘Third generation’ artificial sports pitches have overcome the performance problems associated with early solutions to the problem of an all-weather playing surface.

- The FA allows lower league men’s and women’s football to be played on approved artificial surfaces such as FieldTurf.

- FieldTurf uses ~63mm long pile plastic carpet in-filled with sand and 0.5-1.5mm rubber particles.

- The rubber particles are cryogenically derived from used car tyres. Cryogenic rubber will shortly be available from a UK source, as a new 20,000tpa plant will be commissioned in South Wales in May 2007.

- The advantages of using a rubber-derived artificial playing surface compared to natural turf include increased revenue due to decreased ‘downtime’ of the pitch, lower maintenance costs, greater longevity of the pitch, a more consistent playing surface, and the substitution of a virgin raw material (sand) with a material that would otherwise be waste.

- Around 100 tonnes of rubber is required for a standard football pitch. This equates to around 150 tonnes of car tyres, or 21,000 tyres. This use would potentially divert 4,500 tonnes of tyres per year from UK landfill.
Overview

For sports that are traditionally played on grass pitches, maintaining the even, densely grassed, weed-free surface in any climate requires specialist ground keeping skills and costly materials and equipment. Also, the problems of waterlogged, frozen, or worn out turf can be disruptive to match calendars and lead to further expense. In the mid 1900s the sports and play industry looked to develop an artificial surface which both looks like and performs like grass, but which would be available in all weathers or for indoor use.

Early forms of artificial sports pitches were in the form of plastic carpets which had little resemblance to natural turf in the way that they performed. They were also dangerous to use in that players risked bone and muscle injury and `carpet burns' when falling over on the hard surface.

By the late 1990's, the so-called “third generation” sports surface had been developed to overcome the many problems associated with earlier surfaces. The concept comprises a long pile plastic carpet which is in-filled with a mixture of recycled rubber and sand to form a surface which closely resembles natural grass to play on, and which absorbs the majority of energy during impact, thereby minimising injuries from falls.

Third generation pitches are now in common use world wide, providing the main playing surface for many major sporting clubs, particularly in North America. In the UK, use as the main playing surface is limited to the smaller clubs, but this type of artificial turf is also used extensively in training and youth development academies at the larger clubs, for school and college sports, and in local authority recreational facilities.

This case study relates to the installation and performance of a third generation artificial football pitch at Woodley Sports Football Club based in Woodley, near Stockport. The club is a semi-
professional football team currently playing in Division One of the Unibond League. The pitch is part of a general sports facility installed in 2005 as part of a major redevelopment of the football ground, which will also include additional seating, covered standing accommodation, floodlighting and new perimeter fencing.

Whilst capital cost was high relative to that of a conventional natural grass pitch, the artificial turf has numerous benefits, including low maintenance cost, long life, and all weather availability. Matches rarely have to be cancelled due to inclement weather and the pitch can be hired out for use by third parties for almost seven days per week, providing additional revenue to the club.
Artificial turf: the background

Early versions of artificial grass were in the form of grass-like short pile carpets, designed to provide a decorative surface but not to withstand heavy sport and leisure use. In 1965, technicians at Monsanto Industries developed an artificial grass of short fibre nylon carpet which was suitable for outdoor sport.

The original name of the new surface was Chemgrass and it was installed in 1966 into the Astrodome in Houston, Texas, where the stadium's revolutionary roof made it almost impossible to maintain a natural grass pitch. The first patent for the artificial grass was filed by Monsanto in 1967. Chemgrass was renamed Astro Turf and the patent for Astro Turf was registered in the US at the United States Patent Office in July 1976.

Improvements in the design of artificial grass surfaces led to a “second generation” surface which comprised a polypropylene weave carpet in-filled with sand. In 1981, London soccer club Queens Park Rangers dug up its grass pitch and installed an artificial one. Others followed, and by the mid-1980s there were four plastic grass pitches in operation in the English football leagues. However, they were not successful. The low friction and absorption characteristics of the surface caused the football to fly off of the surface ‘unnaturally’ relative to its performance on natural grass. The players kept losing their footing, and anyone who fell over risked friction burns. Unsurprisingly, one by one, the clubs went back to natural grass.

The “third generation” system, developed in the mid-1990s, was a development from this, utilising a longer fibre length in the carpet and rubber granulate mixed with the sand infill. Developments in the fibre composition reduced friction burns and the rubber acted as a shock pad to absorb impact energy, both from player falls and from the bouncing ball. Some third generation pitches are also laid on a shock-absorbing substructure.
The improved qualities of these new surfaces have been recognised by the international governing bodies of rugby union and football, and they have each amended their rules to allow the use of artificial grass pitches in their competitions. Whilst there are similarities between rugby and football in the ways that players and the ball interact with the surface, other sports, such as hockey, require slightly different surface characteristics. Where artificial grass pitches are used by more than one sport, compromises may be required in the characteristics of the playing surface.

The pitch at Woodley Sports FC that is described in this case study has passed the rigorous tests to meet the Football Association (FA) Standard for artificial pitches. It was required to pass a series of tests, measuring qualities such as ball roll speed, the height of ball bounce, shock absorption and other player interactions with the pitch.

FieldTurf Inc, based in Montreal, Canada, supplies patented artificial grass pitches worldwide. ERDC Group, based in Edinburgh, is the sole supplier of FieldTurf surfaces in the UK and installed the pitch at Woodley Sports FC. High profile football organisations in the UK who have invested in FieldTurf surfaces installed by ERDC include: the David Beckham Football Academy, FC Barcelona, Manchester City FC, West Ham United, Liverpool FC and Arsenal, who are having their third FieldTurf pitch installed early in 2007.
## Technical information

<table>
<thead>
<tr>
<th>Description</th>
<th>Units</th>
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<tbody>
<tr>
<td>Rubber particle size</td>
<td>0.5mm to 1.5mm</td>
</tr>
<tr>
<td>Material Source</td>
<td>Car tyres</td>
</tr>
<tr>
<td>Process</td>
<td>Cryogenic size reduction</td>
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<td>Rubber content</td>
<td>100 tonnes for typical 7,000m² pitch</td>
</tr>
<tr>
<td>Equivalent used car tyre weight</td>
<td>150 tonnes tyres</td>
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<td>Potential UK market</td>
<td>Say 30 installations:</td>
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<td></td>
<td>= 4,500 tonnes tyres p.a.</td>
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Case study: Woodley Sports FC

Pitch construction

Construction of the FieldTurf pitches follows a well established, patented process. After clearing, excavating and levelling the surface, a base of ‘Type 1’ aggregate is laid to a depth of 300mm. Perforated drainage pipes are set in the aggregate at 10 metre centres. A 50mm deep ‘blinding’ layer of fine grit and shingle is then laid to provide a smooth and level base for the artificial turf.

The turf is a geotextile based carpet with polyethylene fibres about 63mm long. This is laid on the prepared surface and the strips are joined by sewing. A layer of 12mm of sand is then spread onto the carpet followed by alternate layers of rubber and sand particles which are then mixed by a spring-tined mixing machine before a final layer of rubber is laid. The total depth of the fill is approximately 50mm, which leaves a few millimetres of pile to protrude from the surface to simulate closely seeded grass.

The rubber particles are between 0.5mm and 1.5mm in size, manufactured from used car tyres by means of cryogenic size reduction. This process involves freezing the tyre shred using, typically, liquid nitrogen, and breaking the shred down into smaller
particles by the use of a system of hammers. Steel and fibre particles from the tyre shred are separated from the rubber during the process. Approximately 100 tonnes of rubber are used in the construction of a standard sized football pitch of 7,000 square metres.

The surface of the pitch is finished by line-marking in the same way as natural turf.
Rubber in-fill

The rubber in-fill used in third generation artificial sports surfaces is tyre derived granulate and powder. FieldTurf has a patent on the use of cryogenically ground rubber for this purpose. The cryogenic process yields rubber particles which have a largely cuboid shape and relatively smooth surfaces. Other systems use ambient ground rubber. In the ambient process, tyre shred is progressively ground down to small particles using grinding and cutting cylinders at, or just above, ambient temperature, yielding particles of irregular shape with very rough surfaces.

Field Turf argues that cryogenically ground rubber is better than ambient ground rubber in that it is heavier, and its cuboid shape helps it to remain in suspension with the sand. Ambient granulate tends to get displaced under heavy footfall and can migrate to the edge of the pitches. The smoother surface of cryogenic rubber also assists the granules to shed water readily, thereby improving the all-weather credentials of the pitch. Ambient rubber tends to retain water with bubbles of air which gives a “spongy” feel and which causes the particles to float under rainfall, and this accelerates the migration of the particles.
The pitch in use

The surface of the pitch looks and feels like natural turf and is playable in all weathers. As such, it is hired out regularly, providing much needed income to the Club. Currently it is in use, for training or matches, for approximately six hours per day, seven days a week. After two years of regular use it is showing no signs of wear, even in the high activity areas such as the goalmouths. The feel of the surface and ball bounce characteristics are very similar to those of natural turf, unlike the old Astroturf, and players do not suffer ‘burns’ or other injuries when falling on the surface. Playing kit also stays clean.

The surface can get slightly hot in summer months with some players having mentioned a warm feel through their boots in hot conditions.
Maintenance

In dryer weather, the surface is occasionally watered to maintain its softness. Otherwise, the only maintenance required is provided by drawing a mixing and aerator unit, comprising a series of rotating blades and a spring tined rake, across the surface every four days or before matches. The mixing/aerator unit is pulled by a small tractor unit. This process re-aligns the ‘grass’ tufts and re-distributes the rubber filler.

Mixing and aeration is followed by drawing a brush over the surface to smooth down the grass tufts. In this way the surface
of the pitch remains perfectly smooth, unlike natural grass pitches where divots can develop causing uneven bounce of the ball.

Brush unit

Line painting is carried out on a regular basis, but no more than would be required on natural grass.

All maintenance operations can be carried out by relatively unskilled operators, thereby obviating the need for skilled grounds staff. This provides considerable financial advantage over natural turf.
Commercialisation

The FieldTurf surface is approved by the international football authority, FIFA, for Champions League football matches in continental Europe.

In England, the FA allows lower league men’s and women’s football to be played on approved artificial surfaces but both they, and the high profile football clubs, have been reluctant to adopt the surface for men’s football league matches in the UK. The more affluent clubs argue that natural turf is the ideal playing surface. In spite of this, ERDC Group reports a growing demand for third generation artificial grass sports surfaces in the UK. This is due largely to the benefits of its low cost, high durability and all weather availability, which is attractive to lower profile sports organisations.

A typical full sized football pitch such as the one installed at Woodley Sports FC uses c.100 tonnes of rubber granulate and powder in its construction. The market for third generation artificial pitches in the UK is not known. However, on the assumption that a minimum of 50 full-size football pitches, or their equivalent, will be installed using this system in any year, the usage of rubber granulate and powder equates to 5,000 tonnes per year. Given that a car tyre contains approximately 70% rubber, and assuming some losses during manufacture of the granulate and powder, this equates to an annual usage of used car tyres of 7,500 tonnes. This is seen by the industry as a minimum figure for potential demand for cryogenic rubber for this application.
Artificial Turf Sports Pitches

Cost savings and environmental benefits

Cost benefits

The quantifiable cost benefits to the user of a third generation artificial grass surface will depend on a number of circumstances. Savings, or increased revenue, compared to the use of a natural grass pitch will accrue from:

- Significantly lower maintenance costs;
- Lower wear rates;
- Reduced maintenance manpower;
- Fewer match cancellations due to inclement weather;
- Greater utilisation of the pitch, minimising the need for separate training surfaces and enabling revenue generation from hiring out of the facility.

Environmental benefits

The key environmental advantage of the use of tyre derived granulate and powder for artificial sports surfaces is in the beneficial use of material from a significant waste stream. Approximately 480,000 tonnes of used tyres are released for reuse or recycling in the UK annually\(^1\). European-driven legislation has effectively banned the landfilling of used tyres from July 2006. Environmentally beneficial applications for recycled tyre rubber are therefore increasingly important to avoid stockpiles of used tyres accumulating.

Additionally, the rubber, which is a waste material, replaces virgin silica sand which was the sole in-fill material in second generation surfaces. The third generation pitches thereby reduce the demand for a non-renewable material compared to the earlier surfaces.

\(^1\) WRAP 2005 Used Tyre Statistics
Health and safety

There are no confirmed health and safety issues arising from either the installation or use of third generation artificial grass sports surfaces. Injury levels seen during the use of earlier systems were significantly lowered by the introduction of the new technology.

However, during 2006 some reports circulating within the sports and play industry in Europe suggested that there was a potential cancer risk from PAHs (Polynuclear Aromatic Hydrocarbons) released from the rubber granulate in-fills in artificial turf.

On behalf of the football authorities, FIFA and UEFA analysed the risk involved by means of a detailed study of the scientific evidence\(^2\). They concluded that PAHs are “not released or at most negligibly released from tyre abradate”. Furthermore, “epidemiological studies conducted by the Health Effects Institute, the World Health Organisation and other investigators do not implicate tyre wear particles in ambient air as contributing to adverse human health effects” such as respiratory and cardiovascular diseases. The research demonstrates that the finer the particles, the greater the surface area and higher potential for chemicals to leach out of the rubber. The majority of the studies have been on higher surface area particles than are used in artificial turf and they have concluded that the release of chemicals from these particles is within acceptable limits. Therefore the larger granules will have even less potential for adverse health effects.

The Sports and Play Construction Association (SAPCA) has convened a working group of UK experts to investigate the situation. SAPCA is continuing with its investigations but a statement issued in July 2006 comments “...our view is that there are negligible additional risks to humans based on theoretical

\(^2\) FIFA, Zurich, 12 July 2006. An Open Letter concerning the potential cancer risk from certain granulate in-fills from artificial turf.
extrapolation - indeed we have not identified from our initial investigation any evidence of reported symptoms or adverse health effects”.

A working party has also been set up by the European Committee for Standardisation (CEN) to further investigate the issue and its deliberations are on-going.

A study, to evaluate the risk of injury in top level football played on third-generation artificial turf pitches compared with natural grass, was reported in September 20063. The report stated “The data show no increase in injury incidence when elite football is played on artificial turf compared with natural grass” and that “from the medical point of view, there is no contraindication to expansion of artificial turf technology”.

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3 J Ekstrand, T Timpka, M Hägglund. Risk of injury in elite football played on artificial turf versus natural grass: a prospective two-cohort study, 3 Sep 2006
Supply chain

This case study relates to a specific type of installation which utilises cryogenically processed tyre rubber. There are, however, many suppliers using ambient ground rubber in third generation sports surfaces. These companies will obtain the rubber from within the UK where possible.

There is currently no commercial manufacturer of cryogenic rubber in the UK and ERDC imports its rubber granulate/powder from Portugal or North America. However, FieldTurf is a partner in a new venture which is building a cryogenic rubber processing plant in South Wales, due to be commissioned in May 2007. The plant will have an annual output capacity of 20,000 tonnes rubber when fully operational, using shredded car tyres as the material source.

It is assumed that future FieldTurf installations in the UK will utilise rubber from this plant.
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