EVALUATION OF RACETRACK SURFACES IN THE THOROUGHBRED HORSE RACING INDUSTRY

By

HARMONY SUZANNE BLACKWELL

A THESIS PRESENTED TO THE GRADUATE SCHOOL
OF THE UNIVERSITY OF FLORIDA IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR THE DEGREE OF
MASTER OF SCIENCE IN BUILDING CONSTRUCTION

UNIVERSITY OF FLORIDA

2009

Dedicated to well-being of racehorses and to those individuals who have offered their continuous support, guidance, and encouragement:

mom + *dad* + *keith* + *rep* + *abb* + *bjb* + *mop* + *m/m* + *the late, bjp*

ACKNOWLEDGMENTS

Throughout the duration of this study, there have been many people who have offered me endless assistance, guidance, and support. I would like to acknowledge that a study of this magnitude would not have been possible without the contribution of these individuals and to express appreciation for every effort would require much space. Therefore, I would like to express gratitude to those who deserve special recognition:

The team consisting of my thesis committee offered the utmost encouragement, guidance, and patience on a daily basis. Dr. Larry C. Muszynski, acting as the first chairman of my thesis committee, expressed much interest from the beginning in the topic of racing surfaces. I would like to thank him for his valuable feedback and maybe one day I will fulfill his request to rush out before a group of fast approaching racehorses to test the compaction of a track surface! Dr. Robert C. Stroh, acting as my second chairman, offered useful statistical reference. Finally, Dr. R. Raymond Issa not only fulfilled the role of the additional member for my thesis committee but also encouraged me since the first days of graduate school to pursue a masters degree in building construction.

I would like to thank Dr. Craig T. Roberts for his valuable insight into the practice of equine medicine and for offering the first connection towards the research I conducted in Ocala.

The racing operations in Ocala that offered their time and permission for my visitations were most helpful in allowing me to intimately watch horses train over the surfaces. I would like to gratuitously thank Eddie Woods with Eddie Woods Stables; Thomas Ventura, Tom Chiota, and Bob Baron with Ocala Breeders' Sales; Milton Hendry with Bridlewood Farm; and Town and Country Farm for allowing me to conduct research and gather material samples of their track surfaces. I would like to express appreciation to the California racetracks – Santa Anita, Hollywood Park, Golden Gate Fields, and Del Mar – which were helpful in obtaining information regarding the construction and maintenance of their synthetic surfaces. The company that manufactures the synthetic material ‘Polytrack’ was especially helpful by providing statistical information and donating a substantial amount of material for my research. I would like to thank the Polytrack representatives Jim Pendergest and Jacy Frey for the synthetic material donation.

On a more personal level, I would like to acknowledge those who are close at heart. I would like to thank Miguel for his endless support and encouragement during this very long journey. I would like to especially thank him for coming with me on that very cold and early morning to visit the racetracks in Ocala and for proofreading this thesis numerous times, for it would not have been as thorough if it wasn’t for your advice. Most of all, I would like to thank him for believing in me during those challenging moments.

Finally, I am extremely grateful for my family. I would like to thank my Mom for her veterinary insight and strong interest in this topic, as I chose it with her in mind. I would like to especially thank my Dad for always supporting me in anything I choose to pursue. I love you and thank you from the bottom of my heart.

TABLE OF CONTENTS

APPENDIX

LIST OF TABLES

LIST OF FIGURES

Abstract of Thesis Presented to the Graduate School
of the University of Florida in Partial Fulfillment of the
Requirements for the Degree of Master of Science in Building Construction

AN EVALUATION OF RACETRACK SURFACES IN THE THOROUGHBRED HORSE RACING INDUSTRY

By

Harmony Suzanne Blackwell

August 2009

Chair: Larry C. Muszynski
Cochair: Robert C. Stroh
Major: Building Construction

Throughout the past few years, the equine racing industry has experienced a consistent cycle of traumatic, life-threatening injuries to Thoroughbred racehorses. Unfortunately, these injuries often occur in the presence of the general public during major races such as the Breeders' Cup, Kentucky Derby, or Preakness Stakes. This exposure of racehorse injuries to the general public poses questions about a horse's training regimen as well as the variations in racetrack footing design and construction. The surface upon which a racehorse is asked to perform affects their speed, quality of movement, effectiveness of exercise, and proneness to injury. It is the shock of impact along with the vertical and shear forces against the surface that affect the delicate bones, muscles, and joints of the racehorse. It is also known that these forces can cause major injuries, which often results in the humane euthanasia of many equine-racing athletes.

Synthetic surfaces are becoming more popular in the equine racing industry because of the expectation they will reduce the number of catastrophic injuries to racehorses. In April 2008, the Welfare and Safety of the Racehorse Summit presented data collected during the previous year that revealed the statistical fatality rates of Thoroughbred racehorses in the United States.

From this report, the fatality rate over synthetic surfaces was 1.47 per 1,000 starts while there were 2.03 fatalities per 1,000 starts over a dirt surface (Curran 2008). In California alone, the Equine Postmortem Program, which is funded by the California Horse Racing Board (CHRB), reported a combined 231 racing and training fatalities during its past fiscal year (Shapiro et al. 2008). Therefore, it is evident that synthetic surfaces are being implemented to provide a safer alternative to conventional racetrack surfaces.

As a result, this innovation in racetrack footing design has allowed the equine racing industry to excel in the choices of surface material. It is also making it possible to provide the most suitable material for the performance enhancement and safety of racehorses. In addition to these benefits, synthetic surfaces are inherently sustainable, as they offer an additional stage in the life cycle of a man-made material that would otherwise be considered waste. It is for these reasons that the research will focus on the variations, attributes, and sustainable characteristics of synthetic surfaces versus conventional dirt surfaces as they are used in the Thoroughbred racing industry.

CHAPTER 1
INTRODUCTION

Throughout recent years, the general public has been consistently exposed to the catastrophic breakdowns of Thoroughbred racehorses during major races such as the Breeders' Cup, Kentucky Derby, and Preakness Stakes. As a result, these unfortunate events raise awareness about the training routine and surfaces upon which the horses are asked to perform. In 2006, the critical hind-leg injury suffered by Barbaro during the Preakness Stakes eventually led to his euthanasia and recently, in the 2008 Kentucky Derby, Eight Belles collapsed and was immediately euthanized after both front legs fractured shortly following her second place finish. With these facts presented, it is evident that synthetic surfaces are being implemented in the equine racing industry as a safer alternative to conventional dirt racetrack surfaces. While the variation between these two surfaces is complex, the results are that they simply save the lives of racehorses.

In the United States, many studies have been conducted to research the nature, type, and history of catastrophic injuries to Thoroughbred racehorses. As a result, synthetic surfaces were introduced to the racing industry as a means to reduce the catastrophic breakdown rate of Thoroughbred racehorses. Since 2005, when the first synthetic surface was installed at Turfway Park in Kentucky, the equine racing industry has observed a reduction in catastrophic injuries in addition to the improved performance of the racehorses being trained over synthetic surfaces. Among the major differences between a synthetic and conventional dirt surface, the primary variation is the materiality of the surface layer. The surface layer of a synthetic system is a blend of man-made, wax coated materials, such as finely chopped polypropylene fibers, rubber band fibers, carpet felt, and automobile tires combined with finely graded silica sand. On the other hand, the surface layer of a conventional dirt system consists of a mixture of dirt, clay, silt, and sand.

The implementation of a synthetic surface is a complex process that involves the collaborative efforts of owners, trainers, breeders, veterinarians, jockeys, and track superintendents. Also, the design and construction of these racetrack surfaces requires knowledge of the various components that are critical for their successful performance. A synthetic system is typically constructed as a series of layers beginning with a loose layer of artificial materials above base layers constructed of porous tar/asphalt, loose gravel, and crushed stone, then placed above a system of perforated drainage pipes. Depending on the manufacturer, the surface layer of this system will differ through the blend of artificial materials.

1.1 Statement of Purpose

The purpose of this thesis is to discuss and compare the design, construction, catastrophic injury statistics, and the costs to install and maintain a synthetic surface versus a conventional dirt surface. The research will target the training and racing operations of the Thoroughbred horse racing industry that are similar to those facilities located throughout Ocala, Florida. Therefore, it is understood that the majority of the Thoroughbred racehorses referenced in this study are being trained over conventional dirt surfaces. See Figure 4-1 for the surveyed results. It is also known that synthetic surfaces are difficult for many training operations to obtain due to the cost of installation, the choice to replace an existing racetrack surface, or the hesitation that it will not relieve the catastrophic injuries suffered by racehorses.

1.2 Objective of the Study

The objective of this study is to evaluate synthetic surfaces and attempt to determine if they are more beneficial for the Thoroughbred horse racing industry than conventional dirt surfaces. The study will identify the material specifications of both types of surfaces and focus on answering the following questions:

- What is a synthetic surface and how is it constructed?
- What is a conventional dirt surface and how is it constructed?
- What are the catastrophic injury statistics of Thoroughbred horses being trained over synthetic surfaces in comparison to those being trained over conventional dirt surfaces?
- What are the costs associated with installing a new synthetic surface or replacing a conventional dirt surface with a synthetic one?

1.3 Scope and Limitations

This study will intently focus on the Thoroughbred horse racing industry as it relates to California, Florida, and Kentucky, as they are prominently known for offering the best racetracks in the industry. They are also the states where the Thoroughbred horse racing industry contributes largely to the economy, where the most research has been conducted regarding synthetic surfaces, and where the most information is readily available. Information will be gathered from visitations to training and racing facilities in Ocala, Florida as well as interviews with racetrack superintendents from the major facilities in California.

The research will identify material composition, statistical injury data, and the costs associated with installing and maintaining the synthetic and conventional dirt surfaces used in the Thoroughbred horse racing industry. Soil and material analysis will be conducted from samples taken from training and racing operations located in Ocala, Florida. General information and survey data collected from professionals who are heavily involved in the training of racehorses and maintenance of the surfaces will help to represent the perception of synthetic surfaces within the industry.

The study will exclude any testing conducted by engineers who challenge the scientific properties of the surface materials, such as vertical stiffness and horizontal shear strength. Also, due to the nature of this thesis and other factors involved, the research will not consider injury statistics other than the catastrophic cases identified by national horse racing boards and associations. Current studies being conducted by veterinarians, trainers, and scientists will also be excluded.

CHAPTER 2
LITERATURE REVIEW

As the information and feedback regarding the use of synthetic surfaces in the Thoroughbred horse racing industry is steadily increasing, it is important to reflect on how it became a popular alternative to a conventional dirt surface. Therefore, the following research examines the history of Thoroughbred horse racing in the United States in addition to the introduction and implementation of synthetic surfaces within the industry. As a result, this chapter is subdivided into the following areas of research: 1) origins of the Thoroughbred; 2) history of Thoroughbred horse racing; 3) beginnings of Thoroughbred horse racing in America; 4) introduction of synthetic surfaces to the Thoroughbred horse racing industry; 5) barriers to implementing synthetic surfaces in the Thoroughbred horse racing industry; and 6) current manufacturers of synthetic surfaces.

2.1 Origins of the Thoroughbred

Before its beginnings in the United States, the Thoroughbred breed was first developed in England around 1690. During this time, over one hundred stallions were imported from Arabia and Turkey to be bred with the characteristically small, heavy mares of England (The History of the Thoroughbred 2004). Among these stallions, three bloodlines are still referenced today as being the foundation sires of the Thoroughbred society – the Byerley Turk, the Godolphin Arabian, and the Darley Arabian. See Figure 2-1 for images of the foundation sires.

The American Thoroughbred was developed in the United States when stallions were imported from England and bred with the native Indian ponies. This cross would eventually go on to produce some of the greatest Thoroughbred racehorses in the world. The American-bred Thoroughbred had its beginnings in 1730, when Bulle Rock was imported from England (The History of the Thoroughbred 2004). In 1798, another Thoroughbred, Diomed, was brought to

Virginia from England and proved to be a breeding success throughout his first ten years in the country. As a result, he became known as the father to many American-bred Thoroughbreds. See Figure 2-2 for Bulle Rock's pedigree and Figure 2-3 for Diomed's pedigree.

Since they were first imported into the United States in 1730, Thoroughbreds have been used for show jumping, dressage, polo, and fox hunting. As they are equally adequate for many disciplines outside of the racing sector, Thoroughbreds are well known for their speed and agility. Physically, Thoroughbreds usually reach a height of approximately 16 hands and a weight of 1,000 pounds (The Thoroughbred 2009). One hand equals four inches; therefore a height of 16 hands is translated to five foot four inches tall. In the racing discipline, Thoroughbreds can reach speeds up to 40 miles per hour, which enables them to cover approximately 60 feet per second (The Thoroughbred 2009). Further physical attributes of the Thoroughbred include a long neck, high withers, deep chest, and a short back set on long, leanly constructed legs. Their strength is often credited to a large heart and strong lungs.

2.2 History of Thoroughbred Horse Racing

Since the seventeenth century, Thoroughbred horse racing has been known as the Sport of Kings (The History of the Thoroughbred 2004). It was during this early time that the Kings of England and their families became heavily involved in the sport of horse racing and were always lending their prestigious support. As the sport developed into a complex weaving of status, class, and wealth, an industry was formed that today, continues to strive in producing an unprecedented list of champion racehorses through breeding and performance excellence. In all, the Thoroughbred remains the primary symbol of the horse racing industry and proves that a tall, slender, and spring-like physicality not only allows for grace and elegance but also for speed and agility.

2.3 Beginnings of Thoroughbred Horse Racing in America

While Virginia was being established as the breeding center of America during the eighteenth century, racing had already experienced its debut on Long Island in 1665 when the royal governor of New York opened the first official racetrack (The History of the Thoroughbred 2004). During the 1690's, the southern colonies followed suit and started opening racetracks. This was followed by the rapid westward expansion of horse racing during the eighteenth and nineteenth centuries when Illinois, Missouri, Louisiana, Texas, and California began constructing grandstands and racetracks. While this expansion of Thoroughbred horse racing occurred before the Civil War, the state of the sport following the war was slightly similar to how it exists today – California and New York were dominated with racing while Kentucky and Tennessee were being established as the breeding centers of the country. See Table 2-1 for a timeline of the development of American Thoroughbred horse racing.

2.3.1 The Game

At the beginning of Thoroughbred horse racing in England, it was customary for one race to consist of three to four heats, each consisting of up to four miles in lengths. These heats were often repeated until one horse had won two of them, therefore proving him the best in the field of horses (The History of the Thoroughbred 2004). It was also not uncommon for the winning horse to have run a distance of 20 miles for one race. Once in America, Thoroughbreds were often run in match races, where two or more horses were raced over shorter distances against each other to prove which one was the best. Throughout the nineteenth century, these types of races were the popular way to race Thoroughbreds and thus facilitated the unfortunate growth of gambling, corruption, and dishonesty within the sport and among its fans.

By the twentieth century, the sport of Thoroughbred horse racing had evolved from a recognized and honest sport to one that was facing out-of-control gambling and corruption. As a result, many states enforced anti-gambling legislation that closed many American racetracks (The History of the Thoroughbred 2004). The officials at Churchill Downs in Louisville, Kentucky felt it was critical for the industry to begin using a betting method that was honest and legal. Therefore, they introduced the pari-mutuel boards in 1908 (The History of the Thoroughbred 2004). This was shortly followed by the introduction of mechanical starting gates and photo finish cameras in 1929 that are still widely used in the horse racing industry. It was these methods and the development of governing associations that helped regain control, order, and integrity of the sport of Thoroughbred horse racing.

2.3.2 Governing Bodies

On February 9, 1984, in New York City, The Jockey Club was formed by numerous owners and breeders aimed at bringing order to American Thoroughbred horse racing (About The Jockey Club 2009). Following The Jockey Club, additional organizations were introduced and began governing the sport to ensure a fair game for all involved. Today, these governing bodies are still enforcing the rules and regulations, monitoring the economic conditions, and working to maintain the integrity of American Thoroughbred horse racing. See Table 2-2 for a list of national organizations that act as the governing bodies for the industry.

The Jockey Club was established in 1894 and acts as the breed registry for all Thoroughbred horses in North America (About The Jockey Club 2009). This means that every Thoroughbred that is born in the United States, Canada, and Puerto Rico is recorded in The American Stud Book, which is regulated by The Jockey Club. The organization has offices located in Lexington, Kentucky and New York City, with many subsidiary companies that act to serve the numerous segments of the American Thoroughbred horse racing industry. These companies are listed as follows: The Jockey Club Information System, equineline.com, Equibase Company LLC, TrackMaster, InCompass, The Jockey Club Technology Services, Grayson-

Jockey Club Research Foundation, and The Jockey Club Foundation (About The Jockey Club 2009).

The Thoroughbred Owners and Breeders Association (TOBA) was established in 1961 with an initiative to improve the economics, integrity and pleasure of the sport of Thoroughbred horse racing with regard to owners and breeders (About TOBA 2009). This association focuses on the recruitment and education of new Thoroughbred owners by offering clinics, seminars, and educational programs. Some of the programs they offer are the Sales Integrity Program, American Graded Stakes Committee, The Racing Game, and the Claiming Crown (About TOBA 2009).

The National Thoroughbred Racing Association (NTRA) was established in 1997 and operates as the largest governing body of American Thoroughbred horse racing. This is partially because they also govern and host the most important racing series in the world – the Breeders' Cup World Championships. The NTRA is an organization that offers legislation for pari-mutuel racing and wagering and participates in a range of programs that address equine drug testing, animal welfare, and sales integrity (Industry Programs 2008).

2.3.3 Racing Season

The Thoroughbred horse racing industry in the United States is comprised of several local and regional environments, each with their own jurisdictions and associations. Although as a whole, the industry operates on two seasonal schedules – the Triple Crown season (Kentucky Derby, Preakness and Belmont Stakes) that runs from February through June and the Breeders' Cup World Championships season, which runs at the beginning of November (Schedules 2009). The remaining portions of the season typically focus on the breeding, selling, and training of the next group of racehorses that will compete to qualify for the prestigious races of the upcoming season.

In the United States, the Thoroughbred horse racing industry operates year-round with several different types, classes, and levels of races offered. Thus races are evaluated and graded on an annual basis by the American Graded Stakes Committee, which is organized by the Thoroughbred Owners and Breeders Association (TOBA). This organization gathers to monitor and ensure that quality racing standards are followed. This committee conducts annual evaluations of the races that are held in the United States to confirm that they offer the highest quality in racing and breeding stock. The races are then ranked according to the grade they earn: Grade I, Grade II, or Grade III, with Grade I being the highest grade and the ranking of the most prestigious races in the country (Graded Stakes 2009). See Appendix B for a list of the Thoroughbred horse races currently being run the United States and when they were first inaugurated.

The Breeders' Cup series has been established as the season-ending championship as well as the richest day in Thoroughbred horse racing (About the Breeders' Cup 2009). A series of fourteen divisional races take place each year in the month of November and award amounts combined are worth over $25 million (Schedules 2009). The Breeders' Cup World Championships are held at a different North American racetrack on a rotating basis every year (About the Breeders' Cup 2009). The Breeders' Cup championships along with the Triple Crown series are the major races that set the stage for the seasons and history-making wins that will follow in the succeeding year.

2.3.4 Racetrack Surface

The first conventional dirt, or 'skinned', surface was introduced in 1821 at Union Race Course on Long Island, New York (The History of the Thoroughbred 2004). It was this racetrack that offered an acceptable departure from the turf surfaces commonly associated with those in

England. In addition, Union Race Course became known as the model for the future ‘fast’ surfaces that were constructed in the United States.

2.4 Introduction of Synthetic Surfaces to the Thoroughbred Horse Racing Industry

In Europe, synthetic surfaces have been in use for over 20 years. They were first considered in the United Kingdom during the winter of 1984-85, when the weather caused the loss of 72 race days (Popham 2007). In the United States, synthetic surfaces have been in use since 2005, when Turfway Park located in Florence, Kentucky installed a Polytrack synthetic surface (Norwood 2006). Following this installation, some of the major racetracks throughout California, Florida, and Kentucky have either resurfaced an existing racetrack or constructed a new one out of a synthetic system. Although of the 129 racetracks across North America, only 7% are currently operating with a synthetic racetrack (Liebman 2007). And even though many racehorses are still experiencing injuries when training and racing over synthetic surfaces, the general consensus is that the surfaces are reducing the amount of catastrophic injuries and breakdowns often seen in the racing industry. It has been documented that owners, trainers, jockeys, breeders, veterinarians, and racetrack superintendents have positively accepted synthetic surfaces, but only to a certain degree.

The introduction of synthetic surfaces into the North American racing industry was undoubtedly due to the catastrophic injury statistics to racehorses (Shulman 2007). At Turfway Park, after one year of installing the Polytrack surface, the track team experienced a nearly 90% decrease in catastrophic breakdowns (Elliston 2006). The significant decrease in serious, life-threatening injuries to racehorses was largely due to the innovative design of the synthetic racetrack system. It provides a surface that is safer and more consistent than a conventional dirt surface, all the while functioning at a level that costs less to maintain (Nicholson 2006). Synthetic surfaces offer consistent footing with minimal kickback and enough cushion that gives under pressure while still offering support as the horse pushes off with their hind end (McFarland 2007).

Furthermore, a synthetic system is designed to be functional and to maintain material consistency in any weather condition, from sleet and snow to rain and extreme heat. The drainage components of a synthetic system are typically located at the bottom-most layer in a vertical arrangement. This is the opposite approach to a horizontal drainage system that is typically used for a conventional dirt racetrack. A vertical drainage system allows moisture to drain straight down through a totally level racetrack, allowing every horse a consistent and dependable surface rail to rail (Nicholson 2006).

2.5 Barriers to Implementing Synthetic Surfaces in the Thoroughbred Horse Racing Industry

Within the horse racing industry, the use of synthetic surfaces has produced a pool of varying opinions and beliefs with much information open to debate. According to the recorded data from injury statistics and interviews with owners, trainers, and veterinarians, the racing industry has only begun to understand the effects of synthetic surfaces. Perhaps one of the strongest arguments for switching from dirt to a synthetic surface is that the artificial surfaces are safer for the horses (Duckworth 2007). In addition to safety, synthetic surfaces tend to favor horses that are typically raced on turf and minimize horses being scratched due to poor surface conditions, as is often experienced with a conventional dirt racetrack. In return, synthetic surfaces have reduced the amount of training days lost to bad weather, allowing an increase in the field sizes of races and the amount of wagering from the fans.

With all of this considered, there are still some barriers to implementing synthetic surfaces for some operations in the horse racing industry. The primary concerns of implementation include the initial cost of installation, maintaining surface consistency between temperature and seasonal changes, and the risk that the change from dirt to synthetic will not relieve the catastrophic injury rate suffered by racehorses. For example, there are synthetic surfaces that seem to be totally different during morning training hours than they are during racing hours (Liebman 2007). And although the catastrophic injuries have greatly decreased, the injuries suffered by horses running over synthetic surfaces have moved higher up in their bodies, such as the hips, shoulders, and necks (Shulman 2007). Is it possible that the implementation of something artificial could harm racehorses rather than help them? Is it necessary to completely change a racetrack system to synthetic or can the sub-layers of a dirt track be reconstructed in an effort to improve the horse's impact with the surface?

2.5.1 Cost

Estimated costs to install a synthetic surface range from approximately $8 million for a Cushion Track surface (Anderson 2007) to $10 million for a Tapeta surface (New Era 2007), with the overall cost of the project dependent on the construction of a new racetrack or resurfacing of an existing one. The initial cost of a synthetic surface is typically offset with the anticipated reduction in maintenance over the lifetime of the surface. For many small-scale training operations across the country, the initial cost of installing a synthetic surface prevents their incorporation into the training of their horses.

2.5.2 Maintenance

Synthetic surfaces are advertised as being a low-maintenance alternative to a conventional dirt surface, which typically requires constant attention (Shulman 2007). The materials used for a synthetic surface are a combination of rubber, wax, sand, jelly cable, and other recyclable ingredients. Determining the right composition for each racetrack has been difficult since the first installation of Polytrack at Turfway Park.

In cold weather climates, the sand begins to separate from the rubber and fiber materials, and the wax separates from the sand. This condition creates a cushiony surface and makes the horses work harder and become fatigued earlier in a race. In warm or hot climates, the surface tends to become harder. For example, the wax becomes more viscous and the track presses down, requiring maintenance crews to rototill it to keep some cushion (Shulman 2007). At some racetrack locations, the morning hours tend to be much cooler than the warm, often 90-degree or warmer, afternoons. With this range of temperature throughout the day, the composition of a synthetic surface alters the speed and performance of the horses running over it.

The level of moisture content within a synthetic surface typically requires little maintenance due to the repelling quality of the wax coating. Also allowing for moisture control is the vertical drainage system located at the lowest sub-layer. Overall, maintenance costs, water use, and manhours have been reduced at the racetracks where synthetic surfaces are being used (LaMaar and Shinar 2007). Although it is important to consider the factors that will affect the composition of the artificial materials used for a synthetic surface and how the reaction will affect the health and performance of the horses being raced. A synthetic surface cannot be installed and left without any attention, especially with regard to temperature and moisture variations (Shulman 2007).

2.5.3 Environmental Impact

In some jurisdictions across the country, there may be governmental regulations that mandate the use of certain materials within environmentally sensitive areas. For example, California's Del Mar racetrack that operates over Polytrack, is located within an environmentally sensitive area and due to regulations, they could not use jelly cable to help bind the synthetic surface (Shulman 2007). Alternately, at the Golden Gate Fields racetrack in California, it is estimated that by having a synthetic surface they will save 30 million gallons of water per year

(LaMarra and Shiner 2007). Less water is needed to maintain an acceptable level of moisture because synthetic surfaces are considered ‘all-weather’ systems.

2.5.4 Track-to-Track Consistency

The use of synthetic surfaces across the country has created just as many biases from trainers as much as they have accepted it. The California Horse Racing Board mandated in 2006 that every California racetrack that operate a minimum of four consecutive weeks of Thoroughbred racing must install a synthetic surface by the end of 2007 (Andersen 2007). Following the installation of a synthetic surface at Del Mar, Hollywood Park, and Santa Anita, a few of the top trainers that usually trained their horses at these tracks moved east to a location where they could still train over a conventional dirt surface. Unfortunately, this causes a disruption in the consistency of racing. If a trainer is working their horses over a dirt surface then races them over a synthetic one, there will most likely be varying results in their performance. Therefore, trainers face the biggest adjustment in how to prepare their horses for racing over synthetic surfaces (Haskin 2007).

2.5.5 Risk of Injury

For many North American racetracks, the implementation of synthetic surfaces carries a level of risk as to the level of improvement it will bring to the training of their horses. How much will a synthetic surface reduce the amount of catastrophic injuries to racehorses? Also, what are the new types of injuries, if any, being experienced on synthetic surfaces? For owners, there are concerns about several current issues surrounding the use of synthetic surfaces. They are concerned with the consistency from one track to another and even intra-day consistency at the same surface; confidence in spotting a horse on a track that they know the horse likes; safety of running in inclement weather on any type of surface; and whether the composition of the surface is as important as the base underneath it (Shulman 2007).

The types of injuries that racehorses have experienced over synthetic surfaces have changed in nature and migrated from the lower extremities to higher up in their bodies. Injuries that horses running on a dirt surface did not usually suffer in the past are becoming more common, particularly with hind-end injuries (Duckworth 2007). Although there have been fewer injuries reported in the front end, there have been more reports of back soreness, hind-end unsoundness, and minor soft-tissue injuries, particularly strains and sprains of suspensory ligaments and tendons. It is also important to consider that as horses are raced over a synthetic surface, their hooves impact it differently than when raced over a conventional dirt surface. For example, a synthetic surface does not allow much ability for a horse's hoof to move laterally or medially, as this type of movement is associated with torque or torsion-type injuries (Duckworth 2007).

2.6 Current Manufacturers of Synthetic Surfaces

The companies currently manufacturing synthetic surfaces are Equestrian Surfaces (Cushion Track), Martin Collins International (Polytrack), Andrews Bowden Ltd (Safetrack), Pro-ride Racing Australia (Pro-ride), and Tapeta Footings. All of these companies design and manufacture synthetic surface systems for the horse racing industry worldwide. A strong consistency between the products these companies manufacture is the overall design from the footing surface down to the sub-grade level, with a slight difference being the mixture of man-made materials at the surface level. Also consistent in these synthetic systems is the vertical drainage system located below the base layers.

2.6.1 Cushion Track

Cushion Track footing is manufactured by Equestrian Surfaces, which was formed approximately 20 years ago by a group of companies based out of the United Kingdom. As of 2006, Equestrian Surfaces has installed its synthetic surface at four locations in the United States

– Hollywood Park Racetrack (California), Santa Anita Racetrack (California), Town and Country Farms (Florida), and Cupola Farm (Florida). The blend of Cushion Track's synthetic surface consists of chopped polypropylene fibers, elastic fibers, felt, rubber, and selected fine high grade multi-washed industrial sand, blended and covered with a wax coating (Cushion Track 2007). See Figure 2-4 for a cross section profile and Figure 2-5 for a plan view of the drainage layout for a Cushion Track synthetic surface.

2.6.2 Polytrack

Polytrack footing is manufactured by a joint venture partnership between Martin Collins International and the Keeneland Association. Martin Collins International, originally based out of England, joined forces with the Keeneland Association, an American company with offices located in Lexington, KY. The team set out to revolutionize a new racetrack system that would reduce catastrophic injuries, increase field sizes, and reduce maintenance costs for both training and major racetracks within the United States. The first Polytrack synthetic racing surface installed in the United States was at Keeneland's training track in Lexington, Kentucky. Following this installation, Polytrack has been installed at three additional locations within the United States – Arlington Park Racetrack (Illinois), Del Mar Thoroughbred Club Racetrack (California), and Turfway Park Racetrack (Kentucky) – but has also been installed at numerous training tracks across the country. The Polytrack system is designed to be an all-weather system. It consists of blend of wax-coated materials – silica sand, synthetic fibers, and rubber – installed above a series of asphalt, stone, and aggregate sub-layers and a vertical drainage system. See Figure 2-6 for a section profile of a Polytrack synthetic surface.

2.6.3 Safetrack

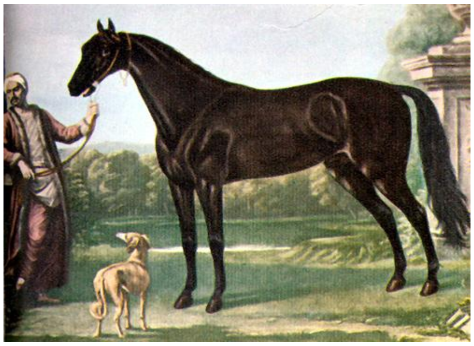
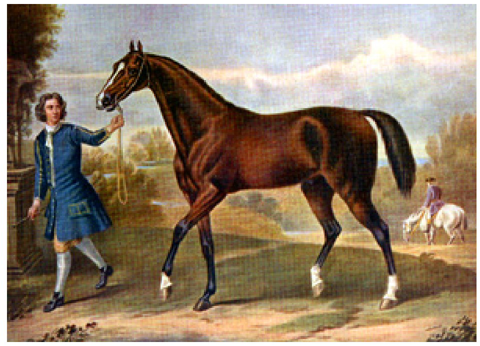
Safetrack footing is manufactured by Andrews Bowen Ltd, which is based out of the United Kingdom with its United States operations located in Ocala, Florida. The first installation of Safetrack in the United States was at the Ocala Breeders' Sales racetrack. In a controlled manufacturing process, the blend of materials used for Safetrack consists of several different types of sand, polypropylene, elastic, and polyester fibers and rubber shred, all coated in a natural wax product (McFarland 2007). As the product name implies, the "SAFE" part of the name actually stands for "synthetic all-weather fiber-enhanced" (McFarland 2007). The sub-layers of the Safetrack system consist of a series of geotextile membranes between layers of limerock and hard clay.

2.6.4 Pro-ride

Pro-ride synthetic surfaces are manufactured by Pro-ride Racing Australia, an Australian-based company located in Melbourne. The only installation of Pro-ride within the United States is at the Santa Anita Racetrack in California. Due to a drainage issue from a previously installed synthetic surface (Cushion Track), this racetrack was replaced in the summer of 2008 with the Pro-ride system (Synthetic racetrack surfaces 2008). Pro-ride is designed as an all-weather material with minimal kickback and a two-phase cushioning technology that provides a consistent surface and a reduction of injuries in racehorses. Unlike the products previously discussed, Pro-ride is not a wax-coated material. Instead, the sand components are coated with a polymeric binder, which allows for moisture and cushioning consistency. See Figure 2-7 for section profiles of a Pro-ride synthetic surface.

2.6.5 Tapeta

Tapeta synthetic surfaces are manufactured by Tapeta Footings, which is located in Maryland. Originally designed in 1998 by trainer Michael Dickinson, Tapeta offers a wax-coated blend of sand, rubber, and fibers that are designed to withstand severe weather. The locations of installations at racetracks within the United States include Golden Gate Fields Racetrack (California) and Presque Isle Downs (Pennsylvania). Tapeta has also been installed at numerous training racetracks located within and outside the United States. See Figure 2-8 for a section profile of a Tapeta synthetic surface.

A   B

 C

Figure 2-1. Foundation sires of the Thoroughbred breed. A) Byerley Turk, B) Darley Arabian, C) Godolphin Arabian. (Source: http://en.wikipedia.org/wiki/Thoroughbred).

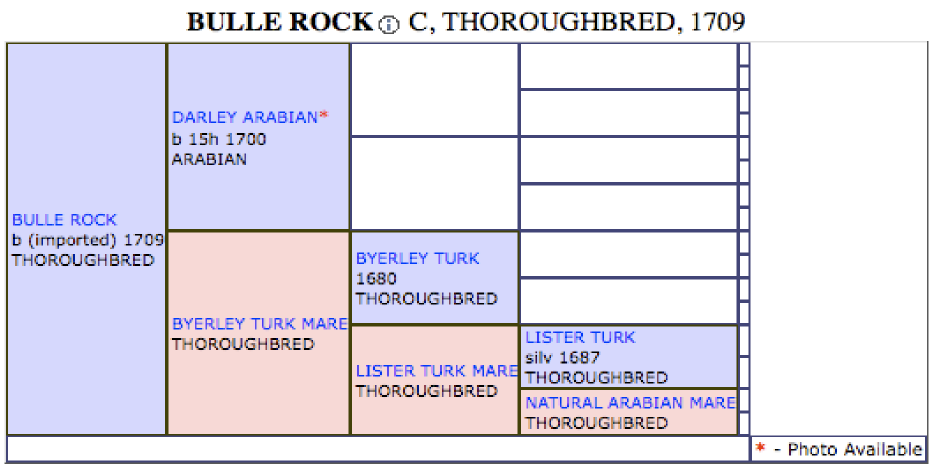


Figure 2-2. Pedigree of Bulle Rock. (Source: http://www.allbreedpedigree.com/bulle+rock).

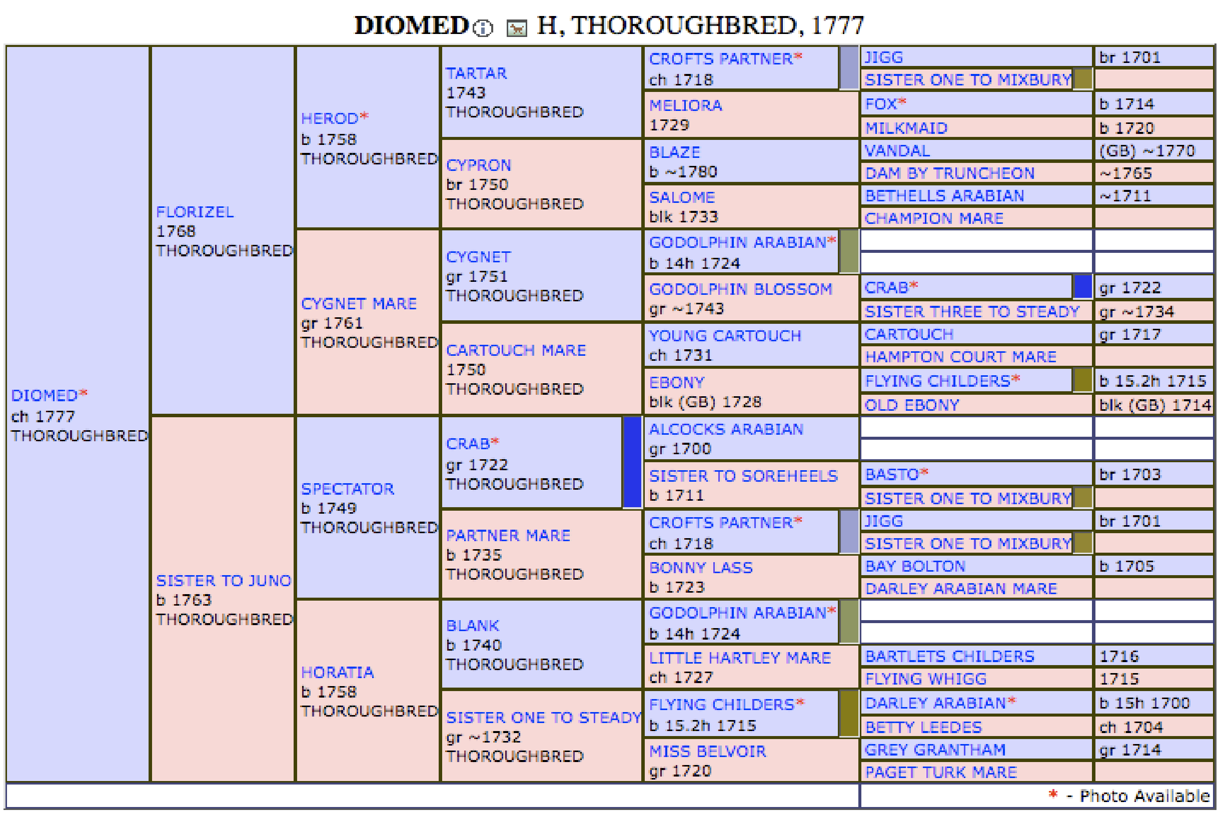


Figure 2-3. Pedigree of Diomed. (Source: http://www.allbreedpedigree.com/diomed).

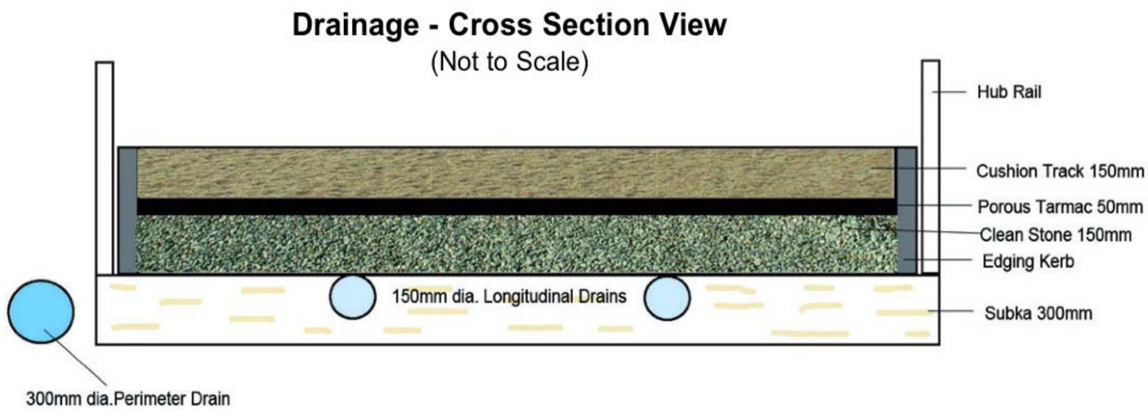


Figure 2-4. Section profile of a Cushion Track synthetic surface. (Source: www.cushiontrackfooting.com).

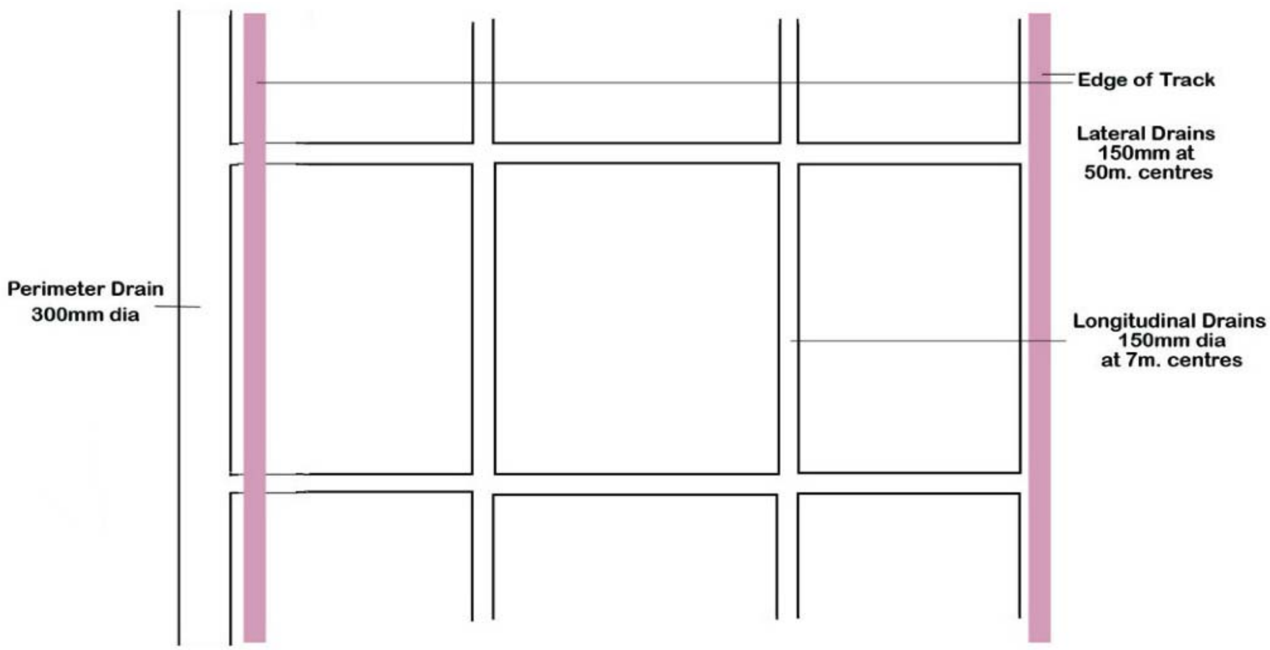


Figure 2-5. Plan view of drainage layout for a Cushion Track synthetic surface. Note: not to scale. (Source: www.cushiontrackfooting.com).

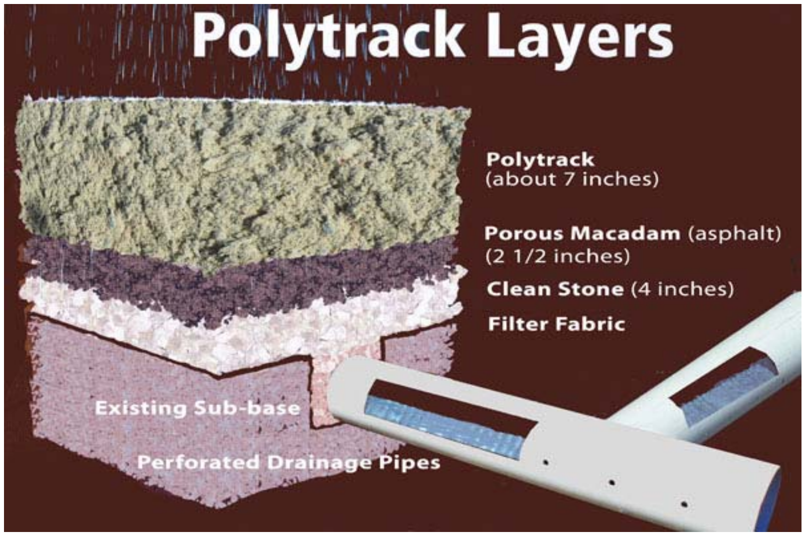


Figure 2-6. Section profile of a Polytrack synthetic surface. (Source: www.polytrack.com).

Figure 2-7. Section profiles of a Pro-ride synthetic surface. (Source: www.prorideracing.com).

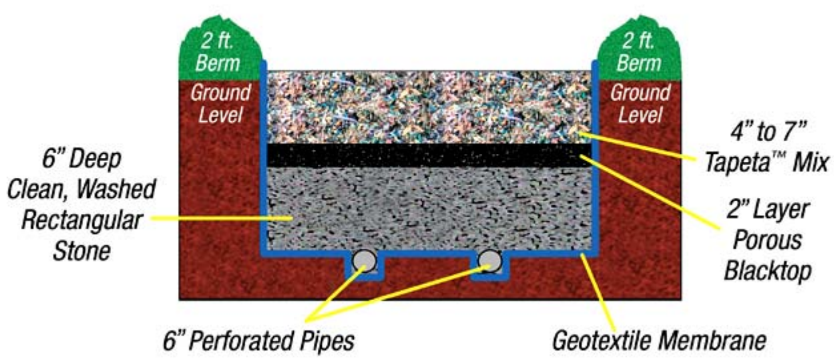


Figure 2-8. Section profile of a Tapeta synthetic surface. (Source: www.tapetafootings.com).

Table 2-1. Timeline of Thoroughbred horse racing in America.

Year	Location	Description
1665	Long Island, NY	A clear pasture was opened as the first official racetrack
1821	Long Island, NY	Union Race Course opened with a dirt track and became the model for all future tracks in America
1840	IL, MO, TX, LA	Began hosting racing events
1848	California	Racing began
1863	Saratoga Springs, NY	Saratoga Racetrack opened during the summer
1866	New York, NY	Jerome Park Racetrack opened and served as the headquarters for the American Jockey Club
1875	Louisville, KY	Churchill Downs opened with the first Kentucky Derby
1908	Louisville, KY	Churchill Downs began using pari-mutuel boards for placing bets
1929		Mechanical starting gate replaced traditional starting line or tape
		Photo-finish camera was introduced to document every finish on film
1930		Triple Crown racing series was created to link three classic races: Kentucky Derby, Preakness Stakes, and Belmont Stakes

Table 2-2. List of national organizations governing the American Thoroughbred horse racing industry.

Name of organization	Year established	Location	Purpose
The Jockey Club	1894	New York, NY	Breed registry for all Thoroughbreds borned in North America; maintains The American Stud Book; dedicated to improving Thoroughbred breeding and racing[1]
Thoroughbred Owners and Breeders Association (TOBA)	1961	Lexington, KY	National trade organization for Thoroughbred owners and breeders aimed at improving the economics, integrity and pleasure of Thoroughbred horse racing[2]
National Thoroughbred Racing Association (NTRA)	1997	New York, NY	Non-profit membership and trade association aimed at increasing popularity of Thoroughbred racing and improving the economic condition in the industry[3]

[1] www.ntra.com
[2] www.toba.org
[3] www.ntra.com

CHAPTER 3
METHODOLOGY

The objective of this thesis is to determine if the synthetic surfaces currently being implemented in the equine racing industry are effective in reducing the catastrophic and career-ending injuries experienced by Thoroughbred racehorses. The methods of data collection range from small to large scale. The data will be collected from one-on-one interviews with racetrack superintendents, veterinary specialists, trainers, riders, and owners. The remaining data will be collected through soil and material analysis, veterinary and product manufacturer journal articles, and a survey of randomly selected training operations located in Ocala, Florida. The aim of these methods is to compare the feedback about the use of synthetic surfaces with conventional dirt surfaces as well as the overall effectiveness and advantage of synthetic surfaces to the Thoroughbred horse racing industry.

3.1 Survey

A survey was sent in the form of a questionnaire to training operations in Ocala, Florida. The city of Ocala is located in Marion County, which in 1997 exceeded all U.S. counties in the total number of resident horses and ponies to become known as The Horse Capital of the World (Fleischhaker 2009). With its large equine population and close proximity to the University of Florida, it seemed feasible and beneficial to perform a survey of this area. Of the various breeding and training disciplines within the equine industry, the survey targeted the Thoroughbred racing discipline only and those operations with detailed profiles listed in the online directory provided by the Florida Thoroughbred Farm Managers, Inc. (2008 Farm Directory). The survey excluded the operations that did not list any specific information about their equine discipline or racetrack specifications, such as length or type of surface.

3.1.1 Survey Population

The survey was sent to approximately 265 Thoroughbred horse racing operations located in Ocala and the data were collected from responses to the questionnaire. The operations were randomly selected regardless of the size of the training facility, the number of horses in training, or how intensely the racetrack was being used. A subset of the entire population contains possible candidates that are valid for analysis. The candidates that were excluded from the population are the responses indicating that they are no longer operating a racetrack or the surveys that were returned undeliverable. The time allotted for the survey was approximately three weeks, with the dates of data collection ranging from 24 October 2008 to 14 November 2008.

3.1.2 Design of the Survey

The survey was developed in the form of a questionnaire containing fifteen questions. These questions were open-ended to allow for the explanation of the primary surface material and maintenance techniques used by the training operation. Also, the age of and injuries to the horses being trained at the respective operation were open for explanation. The survey excluded questions asking for information about the person responding but it was intended to target owners, trainers, and racetrack superintendents. The survey also excluded questions regarding the training schedule of the horses. The aim of the survey was to obtain information about the existing conditions of the racetrack surface as well as feedback and opinions of the training operations in Ocala. The survey can be found in Appendix C.

3.1.3 Explanation of the Survey

Responses to the survey were collected from the following types of questions:

Surface material: This section included a series of questions regarding the existing, preferred, and origin of the surface material for the operation's racetrack. In detail, the operation was asked to label the primary surface material of their racetrack and if they would prefer the natural or synthetic product. Next, they were asked if they were familiar with the origin of the surface material of their racetrack. The purpose of these questions was to gather information about the preference for the choice of material.

Maintenance: This section included a couple questions regarding the maintenance schedule and moisture management for the operation's racetrack. The purpose of this section was to gather information about the common techniques used to allow for ease of use for training on a daily, weekly, or monthly basis. The overall tone of these questions was aimed at achieving an acceptable level of maintenance.

Racetrack specifications: This section included a series of questions regarding the measured length and angle of the racetrack surface as well as how intensely it was used. The purpose of this section was to obtain data about the size of the racing operation and how it is used on a daily, weekly, or monthly basis. It should be noted that the questions asked if there was anything the operation would like to change about the design of their racetrack.

Demographics of horses: This section included a couple of questions regarding the average age and injuries experienced by the horses being trained on the operation's racetrack. It also asked for the location on the racetrack where the injuries most commonly occurred. The purpose of this section was to gather information about the rate and commonality of injuries on the surface material that was provided by their racetrack.

3.2 Collection of Surface Material Samples

Samples of surface materials were collected from four different training racetracks located in Ocala, Florida. These samples consisted of two conventional dirt surface mixtures and two synthetic surface mixtures. The purpose of gathering two of each type of surface material is to compare one type with its equivalent and its opposite. The following is a list of the facilities from which the samples were taken:

- Conventional dirt surface mixtures:
  a) Eddie Woods Stables
  b) Bridlewood Farm

- Synthetic surface mixtures:
  a) Ocala Breeders' Sales (Safetrack)
  b) Town and Country Farm (Cushion Track)

3.3 California Racetrack Facilities

California experiences an intense season of Thoroughbred horse racing in addition to unique environmental conditions. In 2006, the California Horse Racing Board mandated any racetrack operating with four or more consecutive weeks of Thoroughbred horse racing to install a synthetic surface at their facility. As a result, the four major Thoroughbred racing facilities – Santa Anita, Hollywood Park, Golden Gate Fields, and Del Mar – followed the order and were training horses over a synthetic surface by 2008. It is because of these reasons that this area became a valuable resource for gaining information about synthetic surfaces.

The four Thoroughbred racetrack facilities in California that currently employ a synthetic surface were contacted and asked questions regarding the installation and maintenance of their surface. The questions inquired about the cost to install and maintain the surface, its construction before and after the installation, how intensely the surface is used, and its expected life cycle under the current conditions. The individuals targeted by these questions were the racetrack superintendents, as they are the individuals who are most knowledgeable about how the surfaces perform on a daily basis. The facilities that were available to answer questions were Santa Anita, Hollywood Park, and Del Mar. The facility that was not available to answer questions was Golden Gate Fields. A list of questions that were presented can be found in Appendix D.

CHAPTER 4
SURVEY RESULTS

As previously mentioned, a survey in the form of a questionnaire was sent to approximately 265 Thoroughbred racing operations located in Ocala, Florida. Data were collected from a randomly selected pool of training operations regardless of the size of the facility, the number of horses in training, or how intensely the racetrack was being used. The time allotted for the survey was approximately three weeks, with the dates of data collection ranging from 24 October 2008 to 14 November 2008. A subset of the entire population contains possible candidates that are valid for analysis.

4.1 Survey Response Rate

A total of 52 responses were received over the duration of three weeks. Of the 52 responses, six described that they have not used the racetrack for a few years, are no longer operating a racetrack, or have sold their property. A total of 36 surveys were returned as undeliverable, with 177 surveys not returned at all. In conclusion, the approximate rate of response for the survey was 20%.

4.1.1 Surface Material

This section included a series of questions regarding the existing, preferred, and origin of the surface material for the operation's racetrack. In detail, the operation was asked to label the primary surface material of their racetrack and if they would prefer the natural or synthetic product. Next, they were asked if they were familiar with the origin of the surface material of their racetrack. The purpose of these questions was to gather information about the perspective toward the importance of material choice. See Figure 4-1 through Figure 4-4 for a graphical analysis of the results.

4.1.2 Maintenance

This section included a couple questions regarding the maintenance schedule and moisture management for the operation's racetrack. The purpose of this section was to gather information about the common techniques used to allow for ease of use for training on a daily, weekly, or monthly basis. The overall tone of these questions was aimed at an acceptable level of maintenance. See Figure 4-5 and Figure 4-6 for a graphical analysis of the results.

4.1.3 Racetrack Specifications

This section included a series of questions regarding the measured length, angle of the surface, and intensity of use of the operation's racetrack. The purpose of this section was to obtain data about the size of operation and how it is used on a daily, weekly, or monthly basis. It should be noted that the operation was asked if there was anything they would like to change about the design of their racetrack. See Figure 4-7 through Figure 4-10 for a graphical analysis of the results.

4.1.4 Demographics of Horses

This section included a couple of questions regarding the average age and injuries experienced by the horses being trained on the operation's racetrack. It also asked for the location on the racetrack where the injuries most commonly occurred. The purpose of this section was to gather information about the rate and commonality of injuries on the surface material that was provided by their racetrack. See Figure 4-11 through Figure 4-13 for a graphical analysis of the results.

4.2 Summary

From the data presented in this chapter, it can be summarized that the majority of the racetracks responding to the survey train their horses over a conventional dirt surface. It is also apparent that the respondents prefer a dirt surface to a synthetic one. The maintenance schedules reveal a daily routine of harrowing and watering the surface by manmade methods, with many racetracks incorporating a natural approach to moisture control that is dependent on rainfall. The primary use of the racetracks is for the daily training of two-year-old horses, with the type of injuries experienced ranging in nature as well as where they occur on the track. It is possible that the respondents to the survey may benefit from incorporating a synthetic surface to their training regimen? Perhaps this can be most applicable with regard to maintenance and injury occurrence.

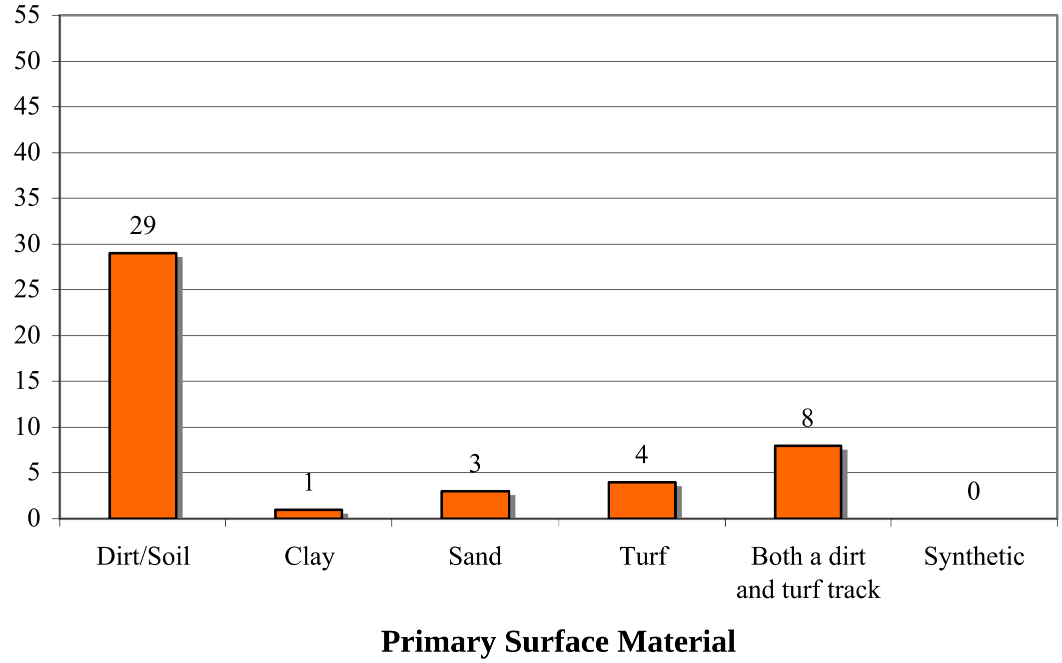


Figure 4-1. Primary surface material of respondent's racetrack.

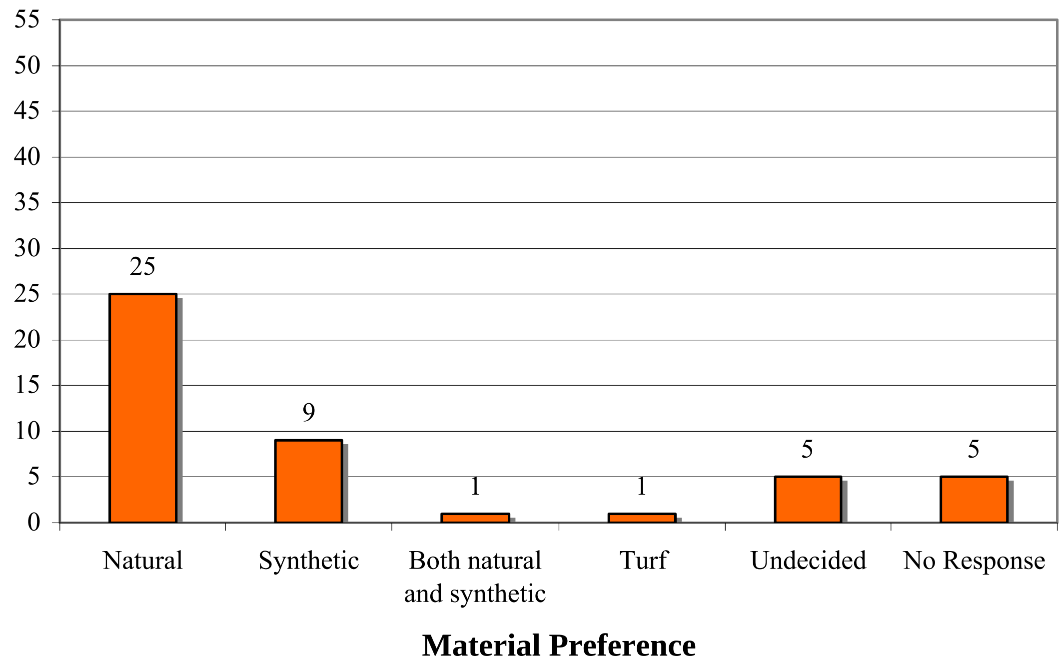


Figure 4-2. Respondent's preference of racetrack surface material.

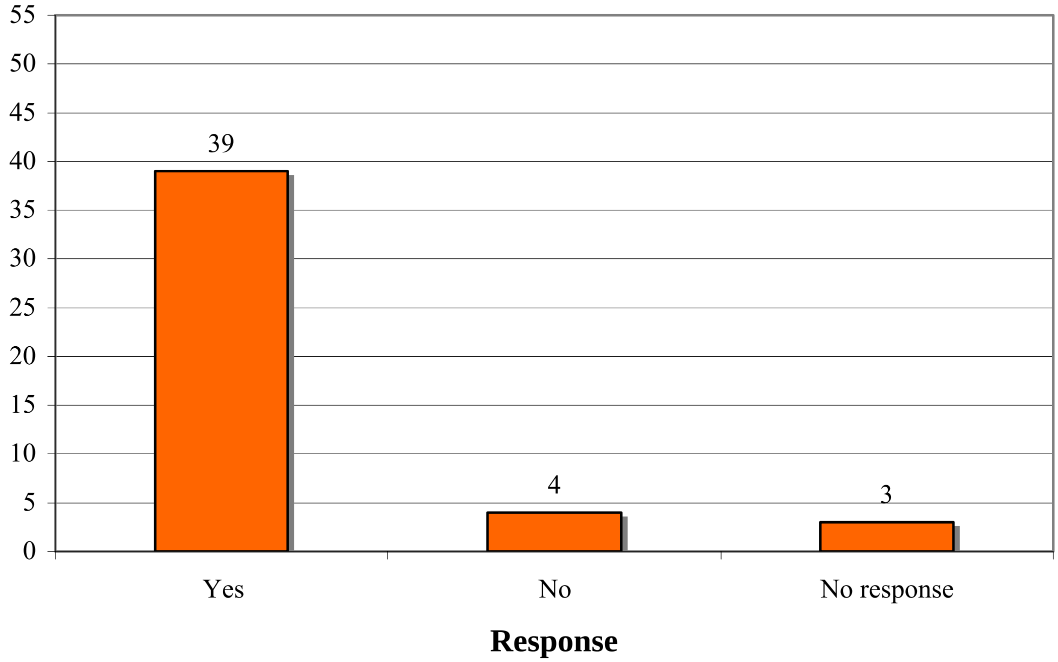


Figure 4-3. Respondent's familiarity with origin of racetrack surface material.

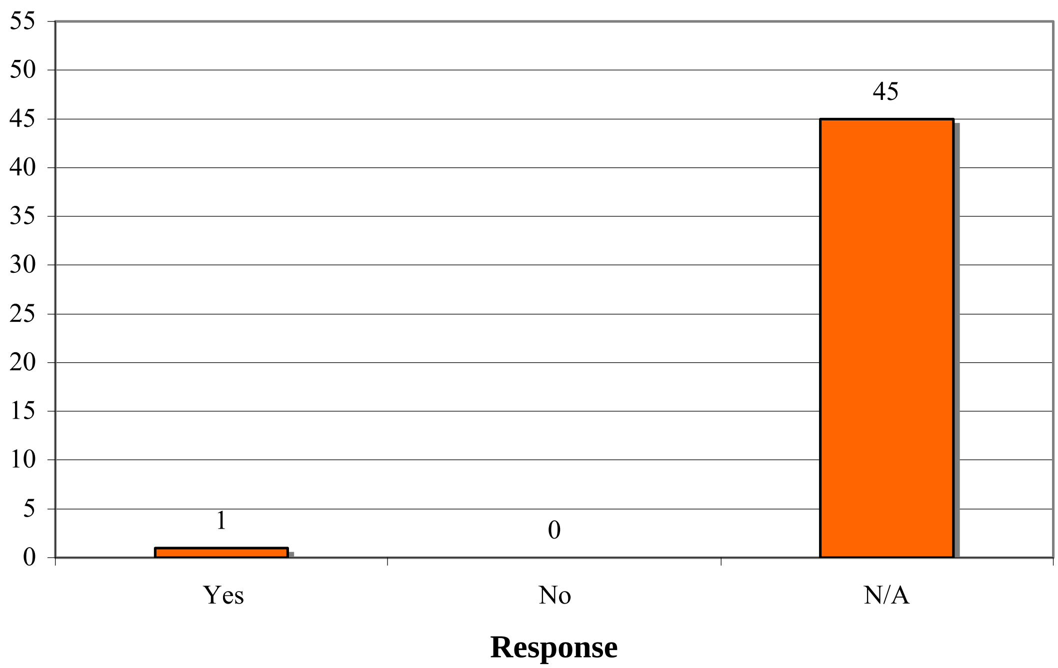


Figure 4-4. Respondent's familiarity with a synthetic product, the manufacturer, and the process of how the product is made.

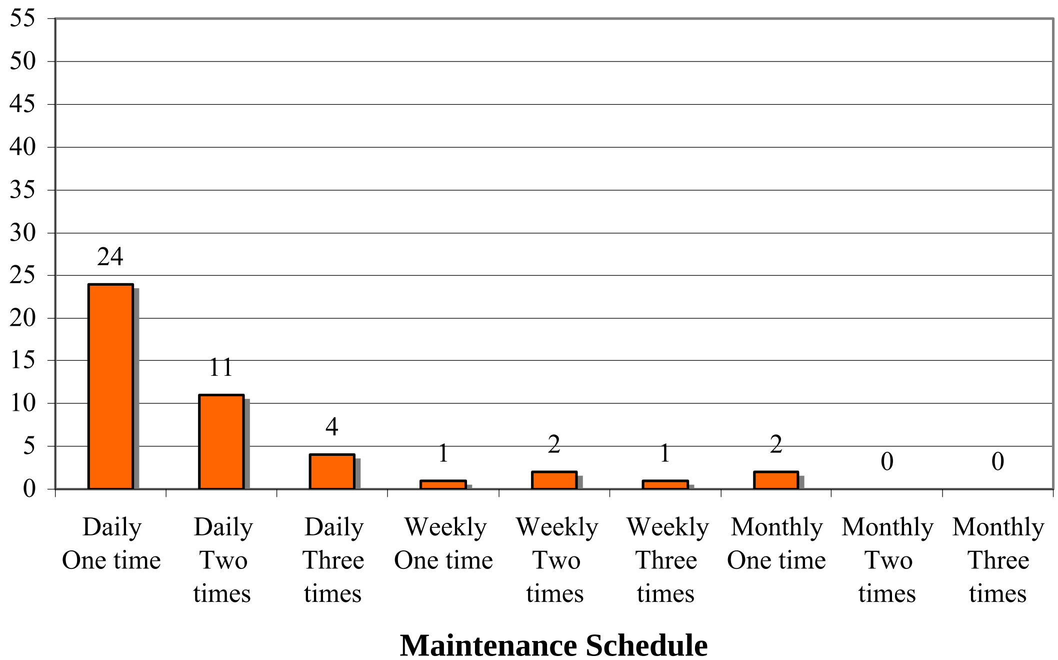


Figure 4-5. Typical maintenance schedule of respondent's racetrack surface.

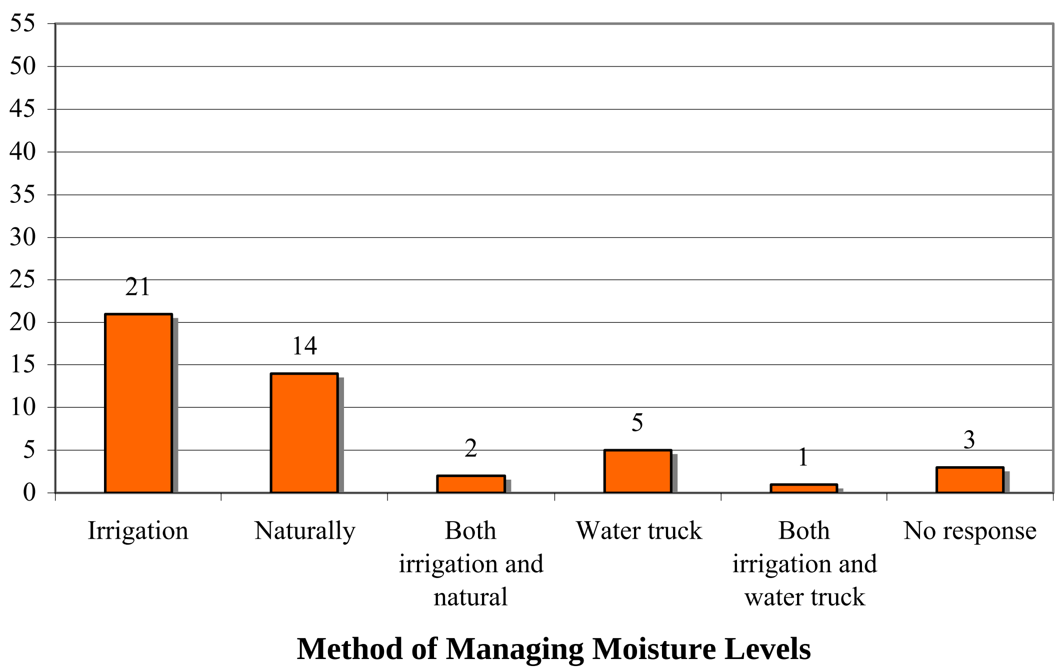


Figure 4-6. Management of an acceptable level of moisture for the respondent's racetrack surface.

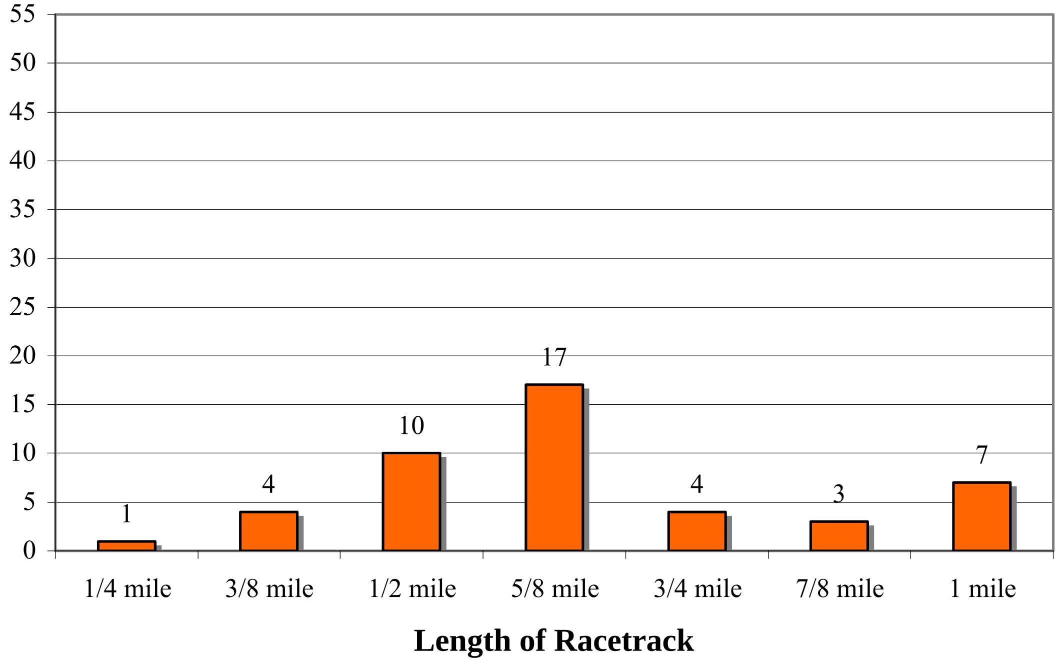


Figure 4-7. Measured length of respondent's racetrack.

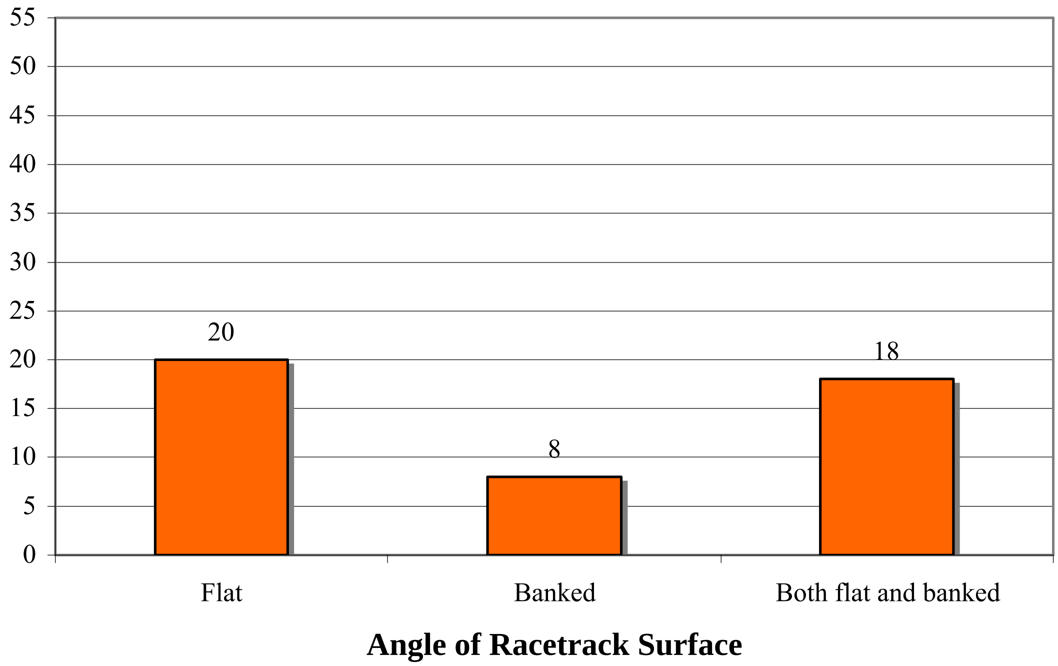


Figure 4-8. Angle of respondent's racetrack surface.

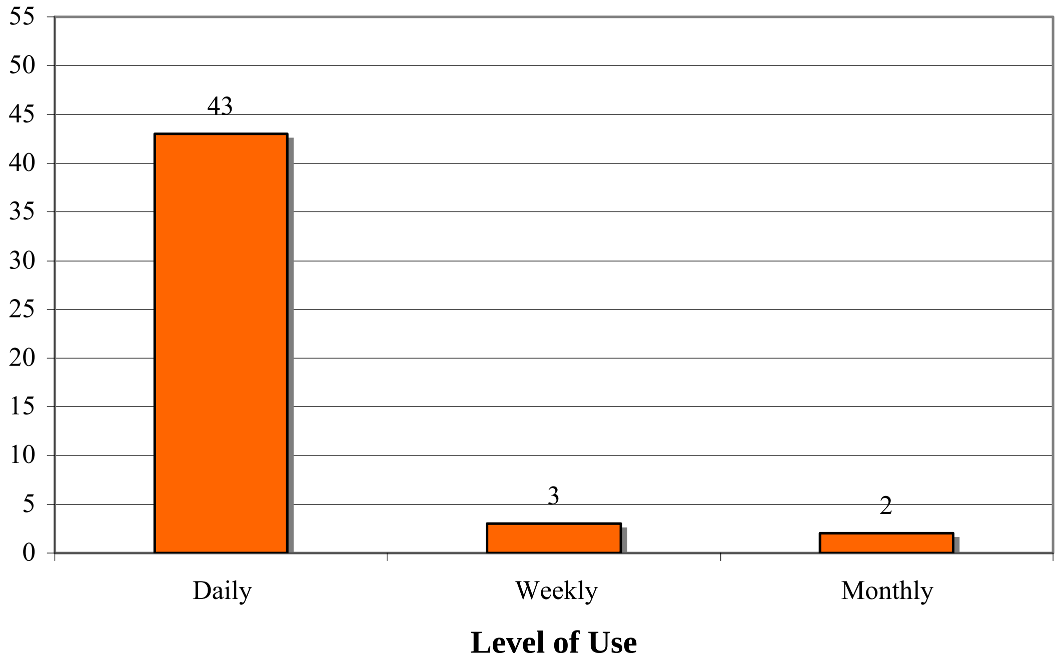


Figure 4-9. Frequency of use of respondent's racetrack.

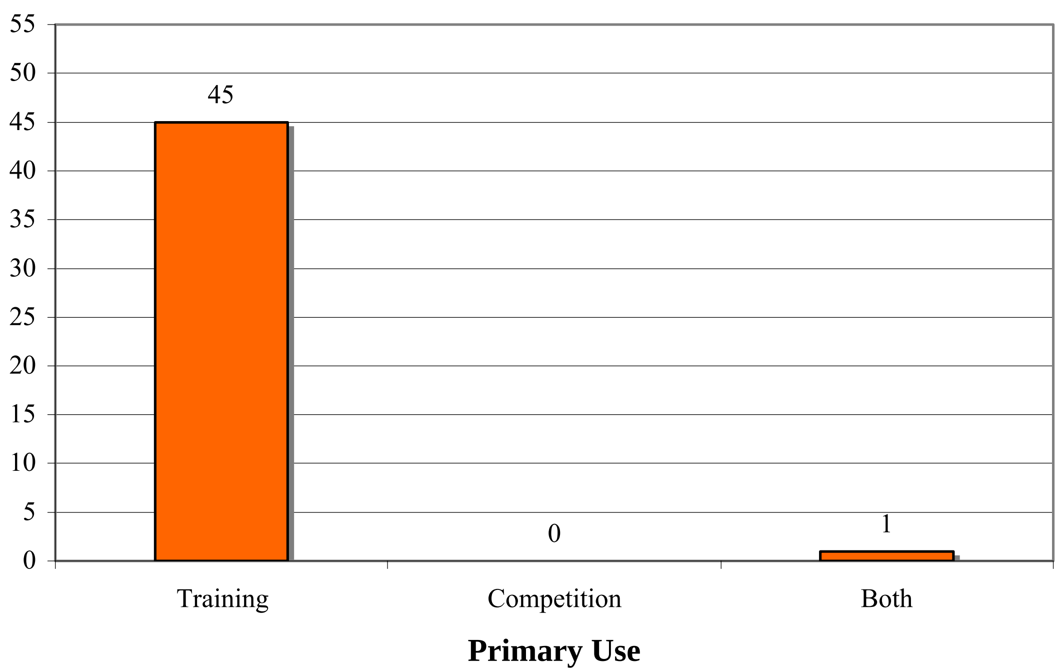


Figure 4-10. Primary use of respondent's racetrack.

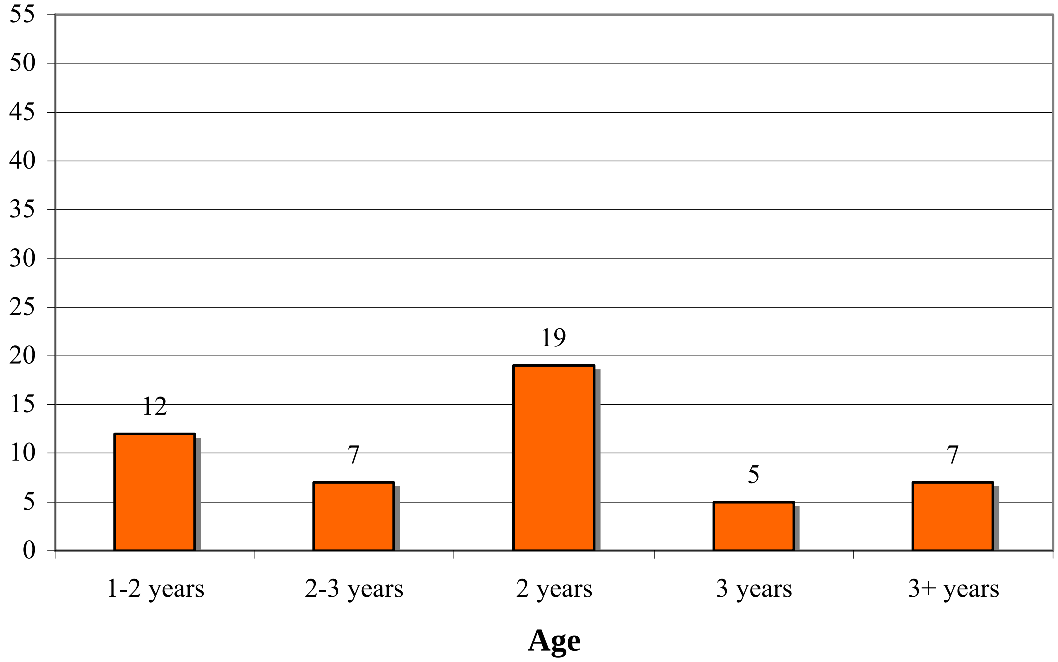


Figure 4-11. Average age of the horse(s) that are run over respondent's racetrack surface.

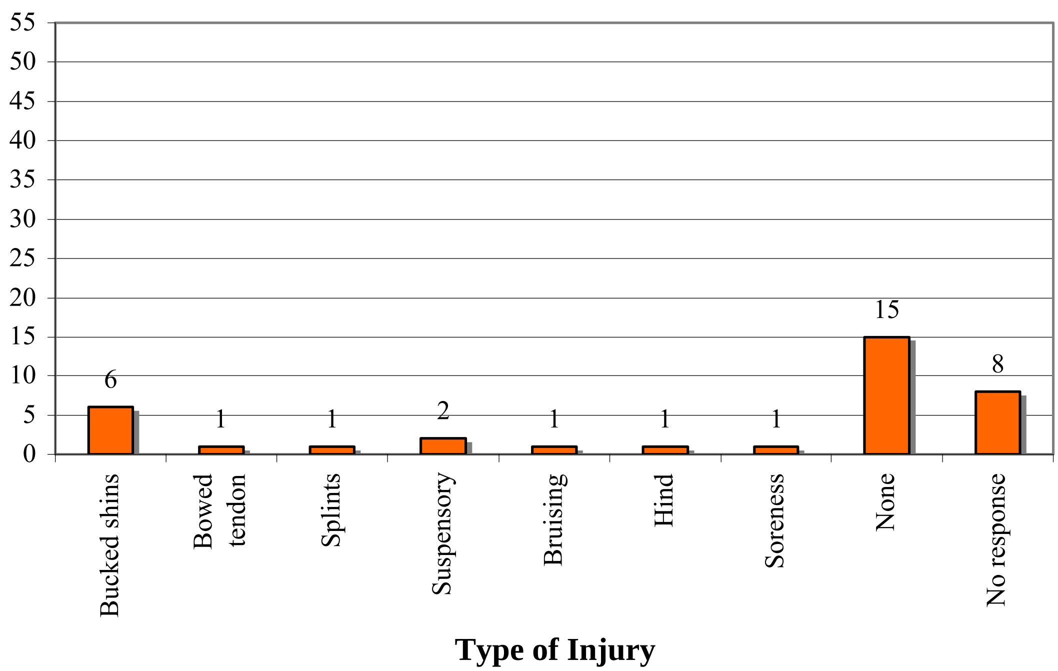


Figure 4-12. Most common type(s) of injuries that the horse(s) experience while running over respondent's racetrack surface.

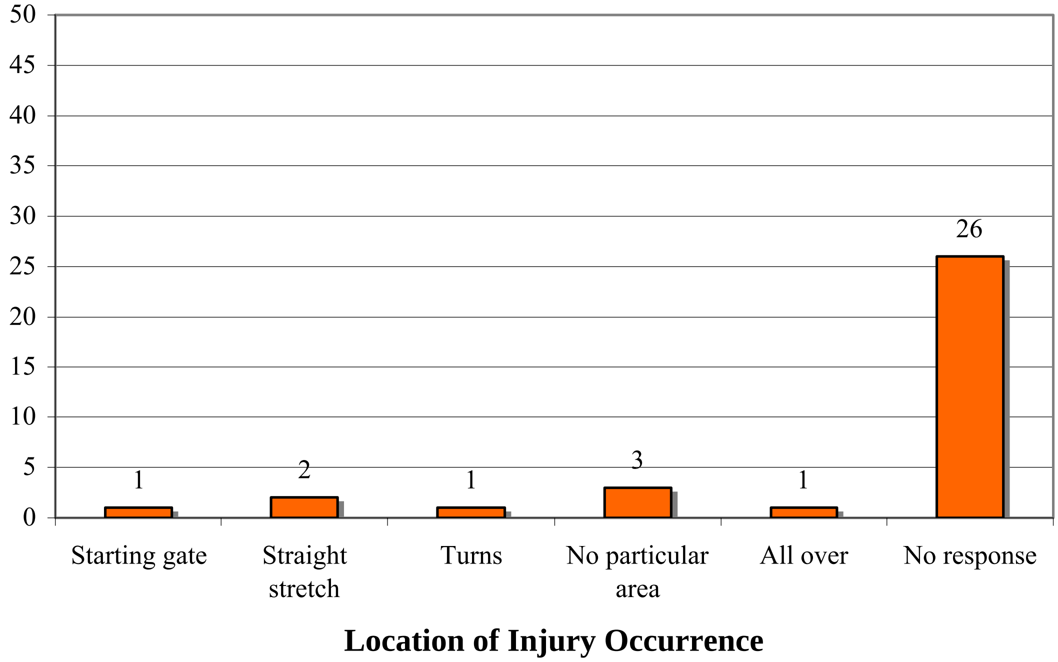


Figure 4-13. Most common location on respondent's racetrack where injuries occur.

CHAPTER 5
CONVENTIONAL DIRT SURFACES

The surfaces upon which horses are asked to perform remains one of the most critical aspects of the game of Thoroughbred horse racing. Since they were first introduced in 1821 on Long Island, New York, conventional dirt surfaces have remained the standard for the design and construction of horse racing surfaces throughout the United States. As the sport of Thoroughbred horse racing has successfully evolved using surfaces made of conventional dirt mixtures, the rate of catastrophic injuries suffered by racehorses has been steadily increasing. Although the surface is not entirely to blame for these results, it is a major factor when it comes to the health and performance of racehorses. As a result, this type of surface has been modified but not entirely successful in trying to better accommodate the training and racing of horses.

5.1 Design

The design of a conventional dirt surface requires knowledge of Thoroughbred horse racing and the importance of these racing surfaces for the industry. The overall standards for the design of a racetrack involve distance as a unit of measure, composition as it relates to materiality, and depth as it relates to cushion and compaction. In a general sense, an adequate length of a racetrack surface used for training is considered to be 5/8-mile, with the radius at the turns no smaller then 275 feet with a preferred radius of 300 feet.

In the horizontal dimension, the design of a racetrack surface involves a distance modulus known as the ‘furlong.’ A furlong is one-eighth of a mile, or 330 feet, in length and is the term used in the horse racing industry to measure distance and record time, both of which determine the speed of a racehorse. The length of a racetrack can vary in one-sixteenth, one-eighth, or one-quarter lengths. See Figure 5-1 and 5-2 for two examples of racetrack plan drawings.

In the vertical dimension, a conventional dirt racetrack is designed as a layered system that is intended to provide an adequate cushion for racehorses while being resilient enough for them to push off and retain their speed. From the ground up, the layers of this system are referred to as the sub-base, base, and top cushion. See Figure 5-3 and 5-4 for section profiles of a conventional dirt surface. The sub-base is often considered the ground upon which the system is constructed. The base is a hard layer approximately six to nine inches deep that functions along with the top cushion to provide an adequate level of compaction for racehorses as they land and push away. The top layer of this system typically consists of an organic mixture that is intended to act as a cushion for racehorses moving at top speed. It is important that this layer maintain an acceptable level of moisture while also draining any excess water from the surface. A hard and dry surface affects a horse skeletally, while a soft and deep surface affects their soft tissue.

The drainage of excess moisture from the surface is facilitated by a combination of banking, or angling, of the surface perpendicular to the inside rail and a drainage system placed strategically around the circumference of the racetrack. The banking of a racing surface is the method by which the outside edge is raised higher than the inside, thus creating an angled surface. This occurs very slightly and is measured in degrees, such as three degrees or five degrees, but usually no higher than seven degrees. See Figures 6-4 through 6-6 for examples of a banked surface from zero degrees to five degrees. A properly designed conventional dirt surface is banked the entire length of the racetrack, with the turns banked slightly higher than the straight-aways.

5.2 Material Composition

The surfaces upon which racehorses train and compete are intended to aid in their speed and performance. The ability for a racehorse to perform successfully is indirectly related to the quality of the surface they are traveling over. However, variations in surface conditions do exist and have the potential to greatly affect how a horse performs. Depending on the intensity of use, ever-changing weather conditions, and the maintenance provided, variations of a racing surface can occur throughout the course of a day or from one day to the next.

According to handicapping principles followed by racing officials, who assign predictable factors for the outcome of a race, the conditions of conventional dirt and turf surfaces are labeled and described using a general list of terms. For the purposes of this study, only the conditions associated with conventional dirt surfaces will be discussed. It is clear from the various conditions listed that the amount of moisture in the surface does not only affect its composition but also the performance and speed of racehorses. The terms used to label the conditions of a conventional dirt surface are listed as follows:

- Fast. This is the surface condition that provides an optimum opportunity for the speed and performance of racehorses. A ‘fast’ track typically offers a dry, evenly graded surface that exhibits strong, resilient characteristics.

- Wet-fast. This surface condition is considered the same as a ‘fast’ track, but with a thin layer of moisture resting at the top of the dirt. This surface is also known to provide an optimum condition for racehorses to perform well and at top speeds.

- Good. This condition is used to describe a surface that is drying out and typically produces slower racing times.

- Muddy. This condition is used to describe a wet, saturated surface that results in a thick top cushion.

- Sloppy. This condition is typical of a wet, saturated surface where water has pooled on top of the dirt cushion.

- Frozen. This condition is a result of a saturated surface that freezes under inclement weather and produces a hard surface.

- Slow. This condition is typical of a surface that is drying out and results in a thick top cushion as well as slow racing times.

- Heavy. This condition is the slowest of all the surfaces, resulting in a very dry and deep top cushion.

The suitability of material for the racing of horses is critical if they are to remain sound, or injury-free, during training or racing. This is particularly important when incorporating local materials into the layers of the system, as the classification or type of sand or clay may not be suitable for the task of horse racing. An ideal blend for the top cushion of a conventional dirt surface consists of approximately 20% silt and loamy sand mixed with 5% clay dirt. This mixture provides an adequate cushion while still allowing the horses to bounce and retain speed as they move over it. Once an appropriate mixture is obtained, it must be managed on a daily basis in order to maintain its composition.

Depending on the geographical location where the racetrack is being constructed, the base layer of a conventional dirt surface is typically constructed of either clay rock or a limestone material. For example, due to the differences in the ground sub-base, the base material used in the construction of a racetrack surface in Florida would vary from that used for a racetrack in California. Due to its drainage characteristics, a limestone-based surface typically requires more water than a clay-based surface. In the northern regions of the country, a clay-based surface may not be suitable because of the shrinking and swelling that occurs as the ground freezes and thaws. In the southern and western regions of the country, this is not usually the case and the climate may allow the use of a clay-based surface. The conventional dirt surfaces located in Ocala, Florida employ local topsoil mixed with clay dirt in the top cushion and a limestone base.

5.3 Construction

The construction of a conventional dirt surface is not entirely different from that of a roadway, with the exception that the top cushion is made soft as opposed to hard. Additional aspects of construction are the planning and layout of the racetrack surface to determine equipment and material quantities needed before any ground is disturbed, as this can highly affect the construction budget.

Initial planning of the construction of a racetrack is crucial to its short-term and long-term expense. The property considered for the location of the racetrack may require preparation before any base layers are installed. Soil tests should be taken at regularly spaced locations throughout the property to determine the depth and types of soil present as well as the location of the water table. Once these tasks are completed, construction of the racetrack can begin.

The season at which the base layers are constructed is highly critical to the performance of the materials. Since these layers typically consist of either a clay or stone, it is important to install them when the environment is most suitable. For example, in the northern regions of the country, this range of time may be during a couple months in the summer while the southern and western regions offer more flexible timing. During installation, the compaction of the base layers should be tested to ensure they meet the design standards set in the planning stage. This concept of compaction is further explained in chapter seven, as the compaction of a conventional dirt material was tested in a similar fashion to roadway construction by using a Proctor density test.

The proper construction of a drainage system is critical if a racetrack surface is to remain safe and functional. Although the design of a drainage system varies from racetrack to racetrack, it is essential to provide areas where excess water can drain away from the surface. An adequate drainage system consisting of pipes that flow to a ditch should be installed into the clay- or limestone-based layer at evenly spaced increments around the circumference of the racetrack. A properly designed and constructed drainage system can also help to minimize the amount of material that is carried away from the surface by heavy rainfall. As with any type of racing surface, the material will shift as horses travel over it and as it is exposed to the natural elements. Hence the incorporation of the drainage system into the surface can help prevent excess water carrying material from the surface.

The equipment used to construct these surfaces is used to compact and grade the sub-base and base layers. It is important to note that the construction of the base layers vary significantly depending on location and availability of materials. In Florida, it is common for the top cushion to consist of a mixture between local topsoil with clay or sandy loam and a base layer of limestone or clay rock.

5.4 Cost

The costs associated with the use of a conventional dirt surface involve short-term costs, such as installation, and long-term costs, such as maintenance. More specifically, the length of the surface and the amount of materials needed to complete the construction determines the short-term costs associated with the installation. The material costs are directly related to the volume of surface materials and linear feet of railing needed. The long-term costs are those associated with maintaining the surface on a daily, monthly, or annual basis. The maintenance of a conventional dirt surface typically involves the purchasing of equipment necessary for the proper conditioning of the surface, the manhours needed to run the equipment, and the continual upkeep of the surface materials.

Additional cost control measures can be taken to ensure the design will work in the space available. This activity can help identify conflicts before they occur during the daily functioning of the racetrack. This is critical to the cost control of the project, not unlike the methods used in the general construction practice of a building.

5.4.1 Installation

The cost to install a conventional dirt surface varies from racetrack to racetrack and it is difficult to obtain an average price. Each surface varies in length, material quality, and construction methods. In a general sense, the cost of installation for a conventional dirt surface, or any type of surface, involves the time required for construction in addition to the equipment and material needed.

5.4.2 Maintenance

The cost of maintenance for a conventional dirt surface is associated with the labor, equipment, material, and management required to properly maintain the surface. More specifically, it is how often the surface needs conditioning, the time required in manpower to run the equipment, and the replacement of surface material as needed. In order to approximate the annual costs for maintaining the surface, it is assumed that it requires at a minimum two tractors, one worker’s salary, payment for the water that is used, and gas and routine maintenance for the tractors.

Depending on the intensity of use, the inside rail of the track will need to be disassembled so the surface can be properly leveled and reworked. The surface near the inside rail is the most intensely used area of the racetrack and gets deeper as horses go over it. Additional material is also added to the surface as the horses, strong winds, or heavy rainfall carry the particles away.

The daily maintenance typically performed over a conventional dirt surface is watering, rolling, grading, and harrowing once, twice, or only when it is needed. The moisture present in the surface is typically managed through the use of a water truck, a water tank pulled by a tractor, or automatic sprinklers located around the circumference of the racetrack. A common sequence of maintenance of a conventional dirt surface is harrowing to level the top cushion, then rolled to compact it down, then graded to bring the cushion back to the preferred depth.

The management of moisture is a challenging aspect with conventional dirt surfaces. They are usually watered on regular weather days but during inclement weather, the surfaces are not considered safe and racing is usually scratched. It is estimated that a racetrack facility in California will use over 50,000 gallons per year in maintaining an adequate level of moisture.

The materials that make up these surfaces only absorb water to a certain degree and the remaining water is left to rest on top or drain to a ditch. This is also the reason why the surface is banked, to allow the flow of excess water away the surface.

The maintenance of a conventional dirt surface involves multiple components and the ability to schedule them in coherence with the training and racing of horses. The typical schedule of maintenance for this type of surface occurs on a daily basis, typically before and after the racetrack is used. There are approximately four pieces of equipment needed to properly maintain a conventional dirt surface. They are listed and described as the following:

- Tractor. This is a standard piece of equipment that a racetrack facility needs for the pulling of equipment. Floatation tires are commonly used to reduce potential surface compaction.

- Track Conditioner. This is a standard piece of equipment used to condition the top cushion of a racing surface by dragging it over the surface with a tractor. The depth of conditioning may range depending on the intended cushion. This piece of equipment is also used to even-out the surface where there are high areas or can be used to redistribute the surface material to lower areas as needed. See Figure 5-5 for an image of a typical track conditioner.

- Track Harrow. This piece of equipment is necessary for a surface to be properly maintained. The steel teeth provide a deep conditioning of the surface as it is dragged over the surface by a tractor. See Figure 5-6 and 5-8 for images of a track harrow.

- Water Truck or Wagon. This piece of equipment is used to provide moisture to a surface. This method is preferred over other common methods used by the industry because the amount of water is able to be controlled. The holding capacity of the water tank ranges but is typically around 2,000 – 3,000 gallons. See Figure 5-6 for an image of water wagon and Figure 5-9 for a water tank and tractor combination.

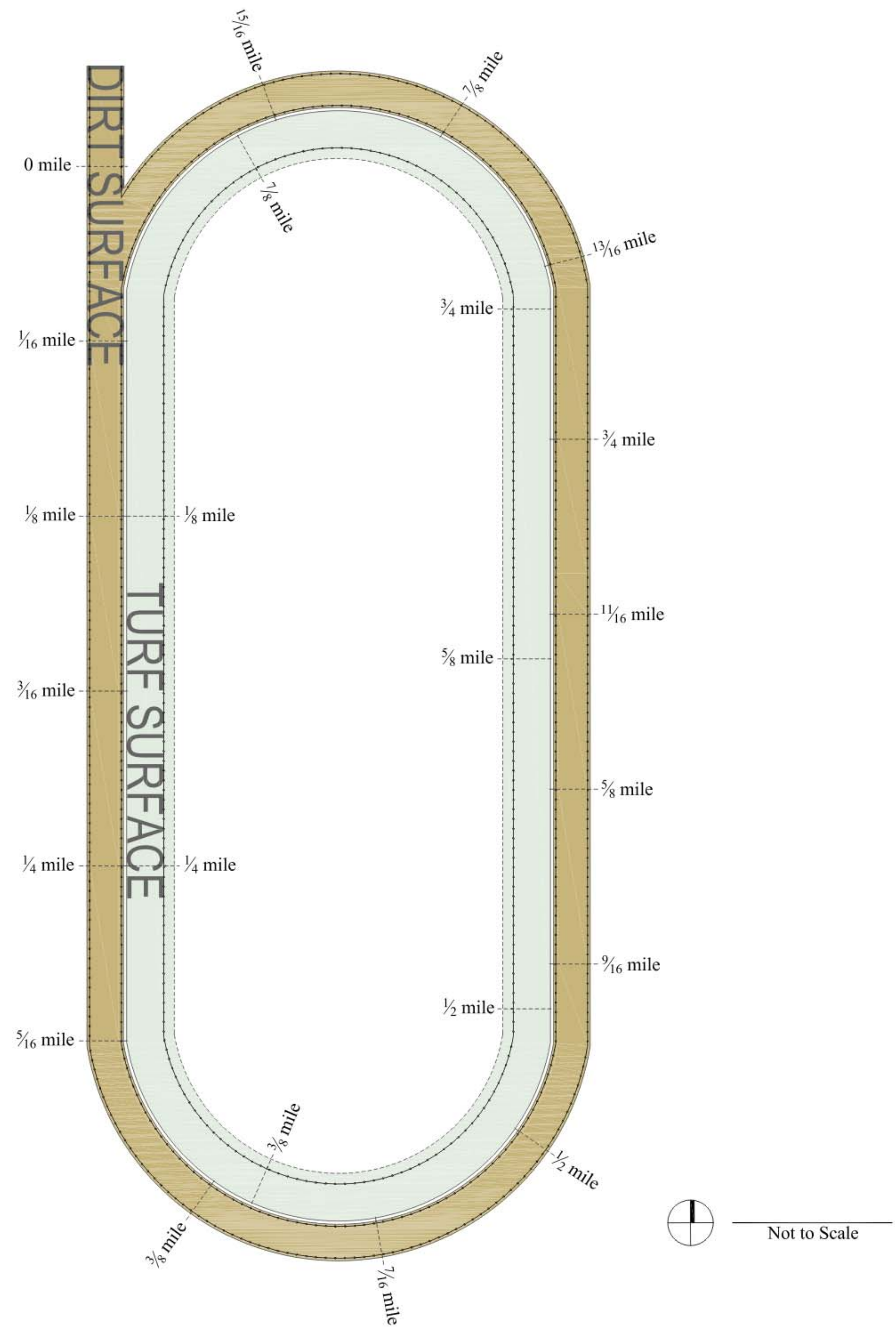


Figure 5-1. Plan of conventional dirt and turf surfaces at Eddie Woods Stables.

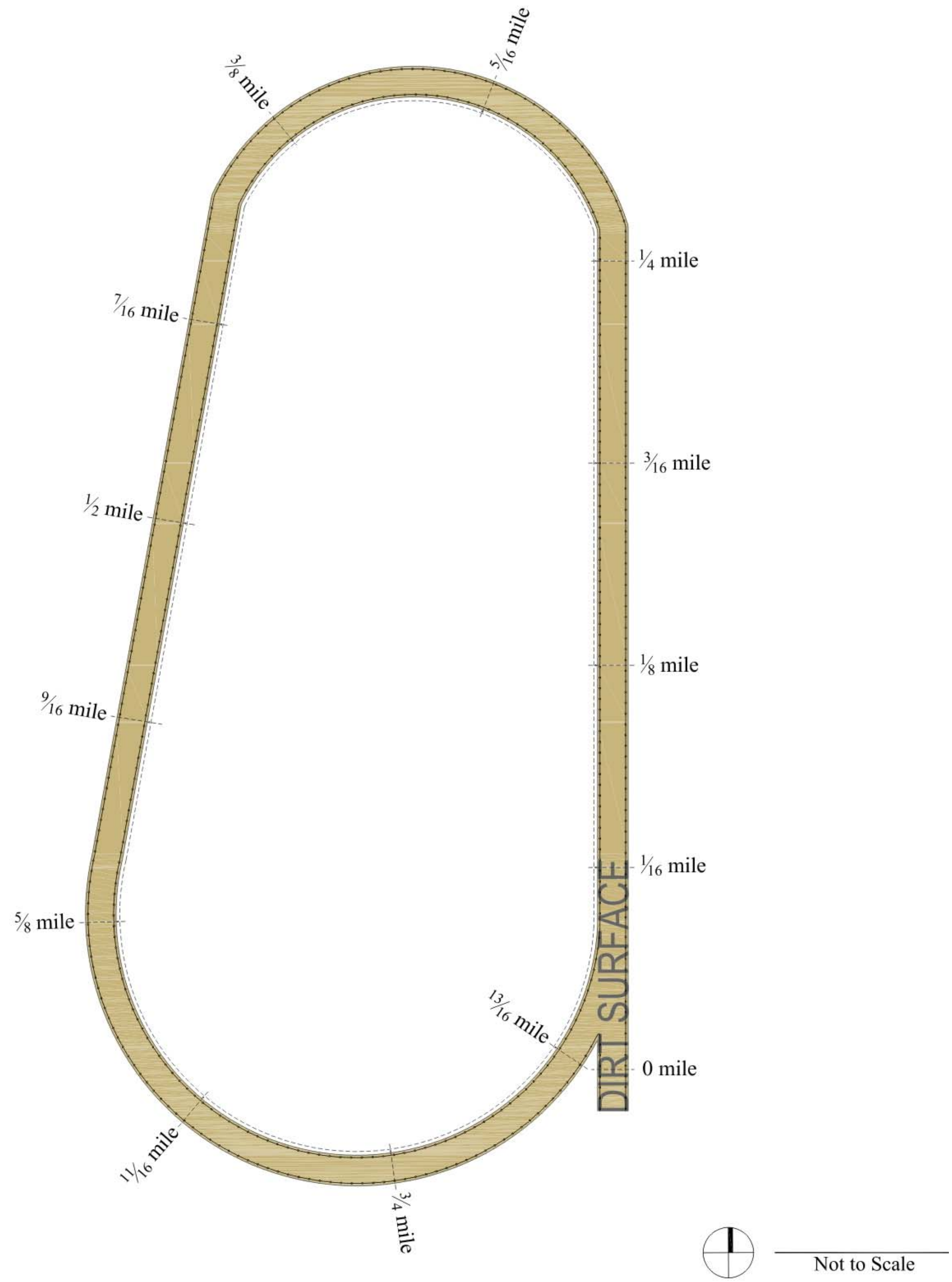


Figure 5-2. Plan of conventional dirt surface at Bridlewood Farm.

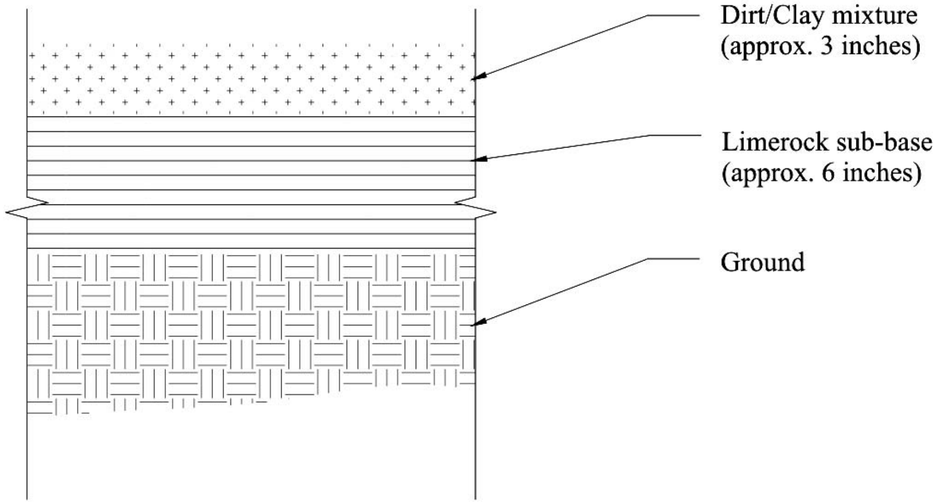


Figure 5-3. Typical profile of a conventional dirt surface.

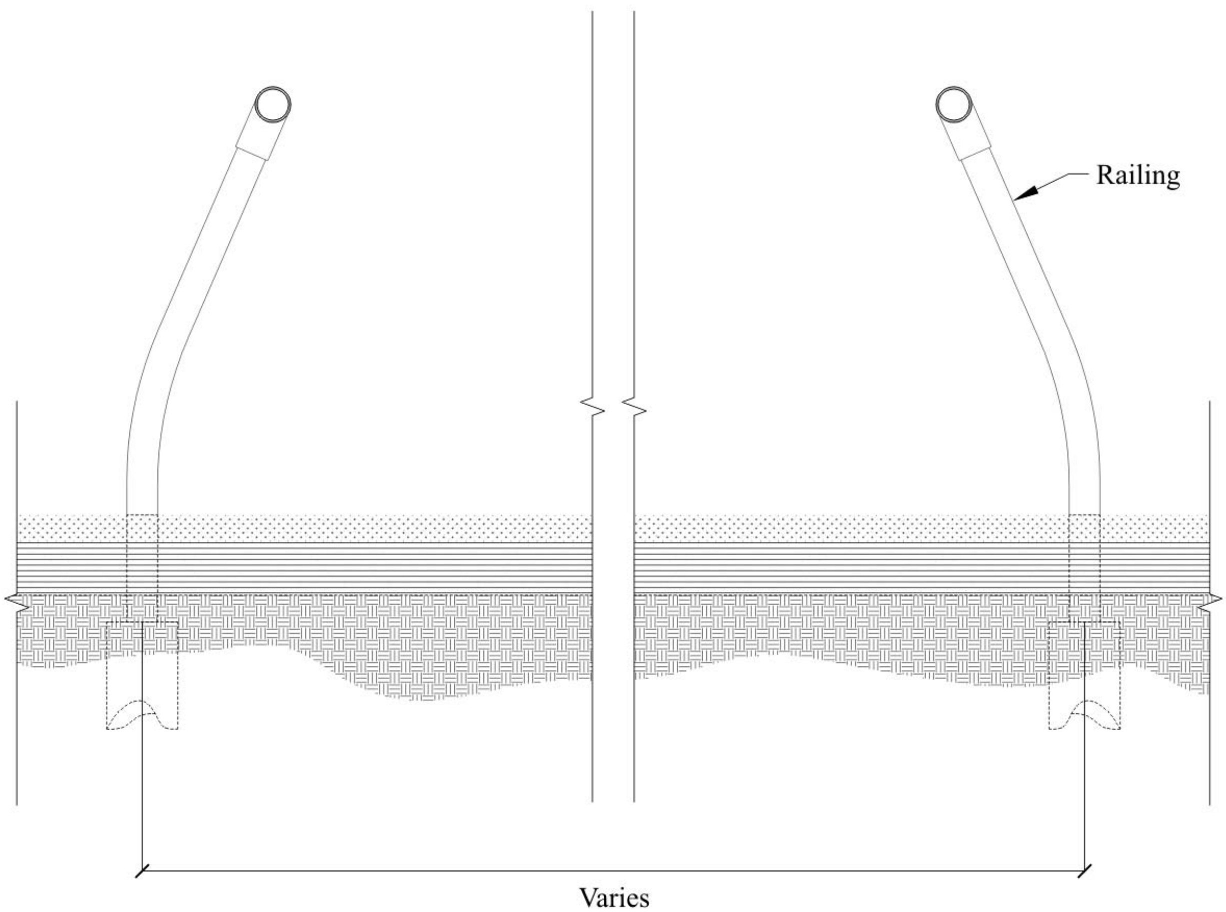


Figure 5-4. Conventional dirt surface profile at zero degrees.

Figure 5-5. Track conditioner. (Source: http://www.horsemenstrack.com/conditioner.html).

Figure 5-6. Track harrow. (Source: http://www.horsemenstrack.com/harrow.html).

Figure 5-7. Water wagon. (Source: http://www.horsemenstrack.com/waterwagon.html).

Figure 5-8. Tractor with harrowing equipment at Bridlewood Farm.

Figure 5-9. Tractor with water tank at Eddie Woods Stables.

CHAPTER 6
SYNTHETIC SURFACES

In the United States, synthetic surfaces were first introduced in 2005 at Turfway Park located in Florence, Kentucky. These surfaces were initially implemented as an alternative to conventional dirt as an attempt to reduce the rate of catastrophic injuries experienced by Thoroughbred racehorses. Compared to conventional dirt, a synthetic surface is a wax-coated blend of organic and man-made materials placed above a series of dense base layers. For the Thoroughbred horse racing industry, this new technology can be incorporated with traditional training methods as a means to relieve the occurrence of catastrophic injuries. It is also a way to improve how the sport of horse racing is viewed with respect to the health and performance of racehorses.

Since they have only been used in the United States for approximately five years, synthetic surfaces have been generally accepted as well as rejected by those heavily involved in the industry. Synthetic surfaces are considered new technology for this country but have been in use in Europe for over 20 years. To a certain degree, skepticism of these surfaces does exist among owners, trainers, veterinarians, and riders who feel horses should only be trained using conventional methods, including the type of surface. Alternatively, there are those within the industry who are willing to try a new technology for the chance it will improve the rates of catastrophic injuries to racehorses.

6.1 Design

A synthetic racing surface is designed to provide a safe, durable, and low-maintenance surface for the task of racing horses. It is designed to also remain suitable under any dramatic variances of saturation or temperature. The intention is that these surfaces not only provide a safer surface than conventional dirt for the training and racing of horses but also function successfully when exposed to intense weather conditions – hot to cold, wet to dry. A synthetic surface is also intended to reduce the maintenance required to bring it back to an adequate condition after intense rainfall or long periods of dry weather.

In the horizontal dimension, a synthetic surface is designed using much of the same methods as a conventional dirt surface. The length of the racetrack is determined using the furlong distance modulus, not unlike a conventional racetrack. See Figure 6-1 for a plan drawing of a synthetic surface.

In the vertical dimension, a synthetic racetrack is designed as a multi-layered system that is intended to provide a dry and level surface under any type of weather condition. The top cushion is typically able to remain in optimum condition at all times because of the strategically placed base layers that exist below. Plastic and felt membranes are placed between the base layers to aid in retaining the drainage, function, and composition of the entire system. A profile drawing of this system can be seen in Figure 6-2.

6.2 Material Composition

The material composition of a synthetic surface is intended to provide consistency under any climatic condition. Throughout the past five years, particularly in California, synthetic surfaces have proven to be sensitive to the environment in which they are placed. In particular, the temperature variance from cool and moist to hot and dry has caused the consistency of a synthetic surface to change dramatically throughout the course of a day. These findings are presenting a challenge to the manufacturers of synthetic surfaces because for the past 20 years in Europe, these surfaces have performed well under various environmental conditions. A possible reason why these surfaces are not performing well in the United States could be that they are used more intensely on a daily and seasonal basis than the racetracks in Europe. This means that the field size of horses and the environmental conditions where the synthetic surface is located should be strongly evaluated before it is installed. It is critical for the success of synthetic surfaces that they are resilient under the conditions that they are placed.

Most importantly, the performance of a synthetic surface under the task of racing horses has shown many different results throughout the past few years in this country. Variations in synthetic products manufactured for the surfaces have shown to react differently under the same environmental conditions. Although this can be associated with the possibility of flaws during construction, the surface itself becomes the primary focus of the problem. Again, it is critical to evaluate the environmental history in a given location to determine if a synthetic surface will perform better than conventional dirt.

At the current time, three out of the five companies that manufacture synthetic surfaces are located and operate within the United States. It is important to note that the blend of organic and inorganic materials incorporated into each company's product will differ slightly but function in much the same way. The environmental regulations within the region where a racetrack is constructed may also warrant the material that is used in the system. The material composition of a synthetic surface involves the combination of soft and hard, and light and heavy organic and inorganic materials. The composition of the surface layer is a wax-coated mixture of finely chopped polypropylene fibers, rubber band fibers, carpet felt, and automobile tires combined with finely graded silica sand. The organic particles consist of the silica sand with the inorganic particles being the man-made components. From the ground up, the base layers of this system consist of a dense grade aggregate with inlaid drainage pipes, porous asphalt, loose gravel, crushed stone, and compact and loose synthetic mixture.

6.3 Construction

The process of constructing a synthetic racetrack follows the same fundamental methods as those described for a conventional dirt racetrack. Whether or not the synthetic surface being constructed is a new racetrack or replacing an existing one, it is essential to draw soil samples to determine the types of soil present and the depth of the water table at the property selected for installation. Minimal planning for the construction of a racetrack can affect the short-term and long-term expenses associated with the surface.

Once construction can begin, the ground is prepared to install the system by making a cut approximately 18 inches deep. The dense aggregate sub-base is then installed and compacted until it forms a hard surface. This layer acts as the foundation of the synthetic system and is also where perforated drainage pipes are laid in a grid-like pattern around the circumference of the racetrack. The incremental grid of the drainage system is dependent on the length and width of the racetrack and pre-determined during the design phase. The pipes are inserted into the aggregate base through the digging of trenches. Once these tasks are completed, loose gravel is placed around the top and sides of the perforated pipes to act as a filter for the water that drains through the system.

The remaining base layer is constructed from asphalt and is installed using similar methods to roadway construction. Once this layer is complete, water is applied to test the drainage of the system that has been constructed up to this point. The cushion of the system is then installed in two layers. Approximately six to seven inches of the synthetic mixture is applied, compacted, and then conditioned to an approximate depth of two to three inches along the top to loosen the cushion.

6.4 Cost

The costs associated with a synthetic surface are slightly more involved than those for a conventional dirt surface. This is because the majority of synthetic surfaces located within the United States have replaced an existing dirt racetrack. Furthermore, the costs for a synthetic surface not only involve the short-term and long-term, but also those associated with the replacement of an existing conventional dirt surface. Alternatively, the costs associated with the daily, monthly, or annual maintenance for this type of surface are intended to compensate for its initial installation.

6.4.1 Installing a New Synthetic Surface

The cost to install a new synthetic surface is dependent on a number of factors such as the location of the racetrack, the length and width of the surface, and the manufacturer providing the services. Since the information regarding the installation of synthetic surfaces is primarily associated with the replacement of an existing dirt surface, it was difficult to obtain an estimate for a new installation.

6.4.2 Replacing a Conventional Dirt Surface

The cost to convert a conventional dirt surface to a synthetic one ranges from approximately four to ten million dollars. This conversion typically involves the total replacement of an existing conventional dirt surface. The existing surface and base layers are removed and replaced with the multi-layered synthetic system. In some cases, a minimal amount of the original racetrack base was retained and incorporated into the new synthetic one.

6.4.3 Cost to Maintain

The costs of maintaining a synthetic surface have shown to be dramatically less than that of a conventional dirt surface. Depending on the intensity of use and environmental conditions where the surface is located, a synthetic surface will only require one four to six man crew working one ten-hour shift daily beginning at around 4:00 a.m. This type of crew will typically drag a power harrow over the surface at the beginning and end of the working shift or as needed to maintain the top cushion. It is also common to run the gallop master equipment at the end of the day after the horses are done training or racing to level off and finish the surface. With a synthetic surface, it is not typically necessary to run equipment during the night, as is commonly performed with intensely used conventional dirt surfaces. With regard to moisture management, an example involving a California racetrack that operates one of the highest volumes of racehorses per season reports a water savings of approximately 40,000 gallons since the installation of their synthetic surface.

6.5 Maintenance

The methods used to maintain a synthetic surface are very similar to those used for a conventional dirt surface, with a few primary differences. Not only is less water needed to manage moisture levels, but also the manpower needed to keep the surface conditioned is not as high. It is known that the wind and rain carry material particles away from the surface but new synthetic material is added to the racetrack as needed to maintain an adequate top cushion. It is clear that this type of racing surface allows for a reduction in overall methods of maintenance. The typical maintenance of a synthetic surface involves the harrowing of the surface to approximately 1 1/2 to 2 1/2 inches deep, depending on how the horses are performing and what their needs are.

6.5.1 Equipment

In addition to the equipment common to the maintenance of a conventional racetrack surface, there are three primary pieces necessary for the proper conditioning of a synthetic surface. See Figure 6-7 for an image of the following pieces of equipment:

- Tractor. This is a standard piece of equipment that a racetrack facility needs for the pulling of equipment. Floatation tires are commonly used to reduce potential surface compaction.
- Gallop Master. This piece of equipment is used to provide a finish condition before or after the use of the surface. The depth of the rake can be adjusted according to preference.
- Track Harrow. This piece of equipment is necessary for a surface to be properly loosened and maintain an adequate depth of cushion. The steel teeth provide a deep conditioning of the surface as it is dragged over the surface by a tractor.

- Rotavator: This piece of equipment is used to refresh the synthetic mixture in the top cushion and maintain an adequate depth of cushion.
- Water Truck or Wagon. This piece of equipment is used to provide moisture to a surface. This method is preferred over other common methods used by the industry because the amount of water is able to be controlled. The holding capacity of the water tank ranges but is typically around 2,000 – 3,000 gallons.

6.5.2 Schedule

The maintenance of a racing surface must coincide with the training and racing of horses. It must be performed before the day begins, in-between fields of horses, and after the surface is finished being used. It is important to note that variations in maintenance schedules do occur depending on the event. If a racing competition is taking place, the surface must be reconditioned between starts in order to provide the field a quality surface. The following is a general schedule that could be applied throughout the course of a day at a training facility that operates most intensely during the morning hours.

- 5:00 a.m. The surface is power harrowed before it is used by any horses.
- 6:00 – 11:00 a.m. The surface is open for training with no maintenance performed.
- 11:00 – 11:30 a.m. Labor is spent removing organic waste from the surface.
- 11:30 – 12:30 a.m. The surface is power harrowed to a depth of approximately four inches, followed by a gallop master to condition and finish the surface to a depth of approximately 2 1/2 inches deep.

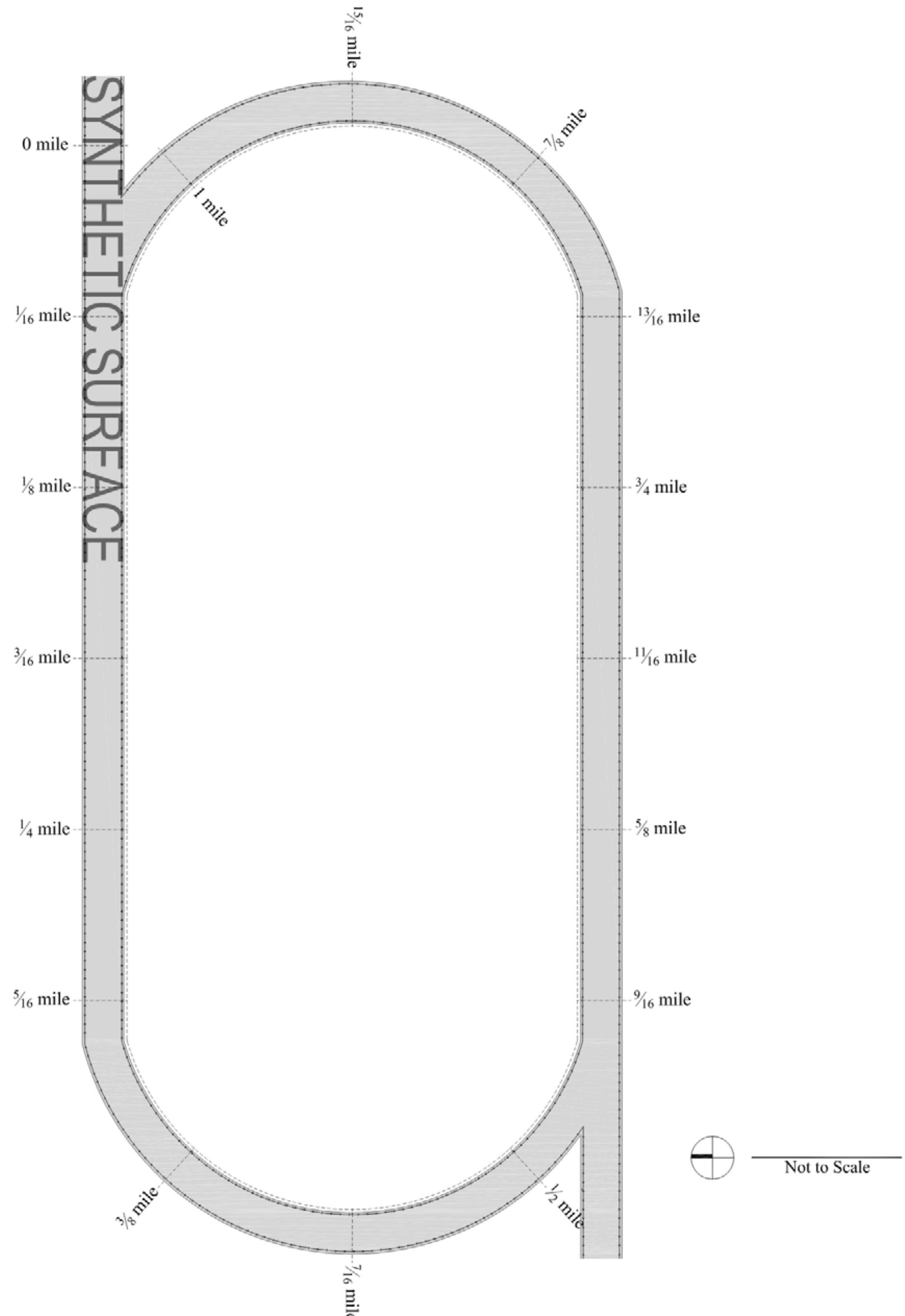


Figure 6-1. Plan of synthetic surface at Ocala Breeders' Sales.

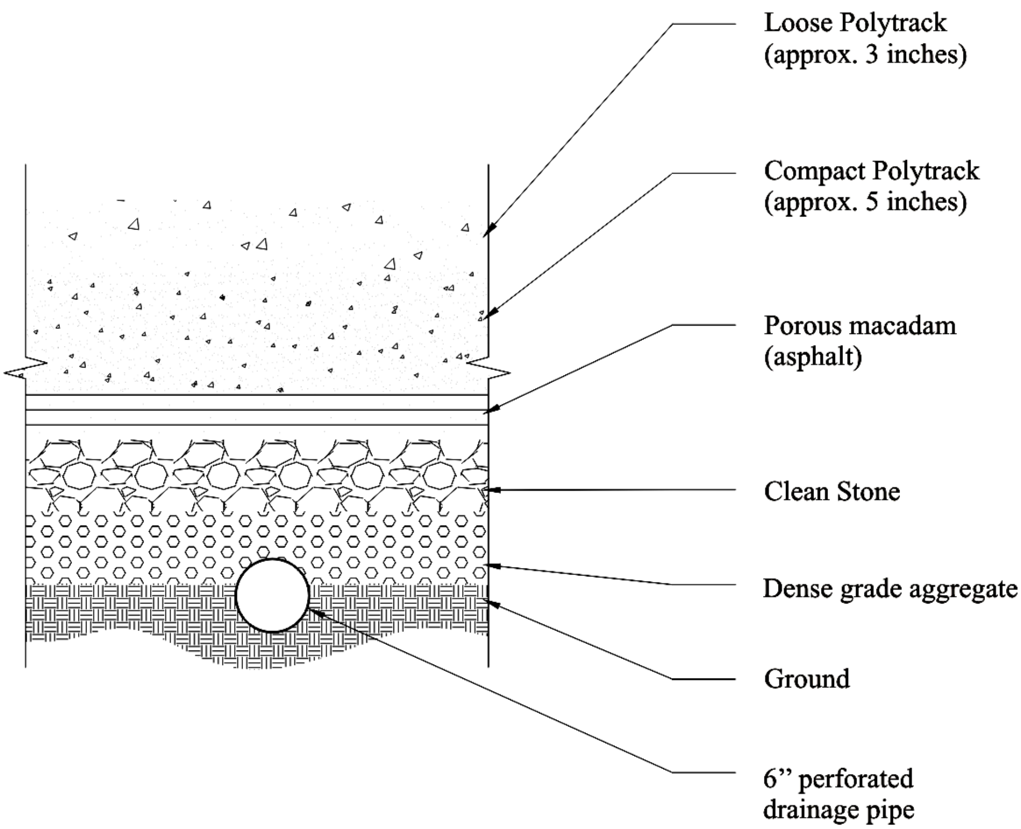


Figure 6-2. Typical section profile of a synthetic surface.

Figure 6-3. Safetrack synthetic surface mockup at Ocala Breeders' Sales.

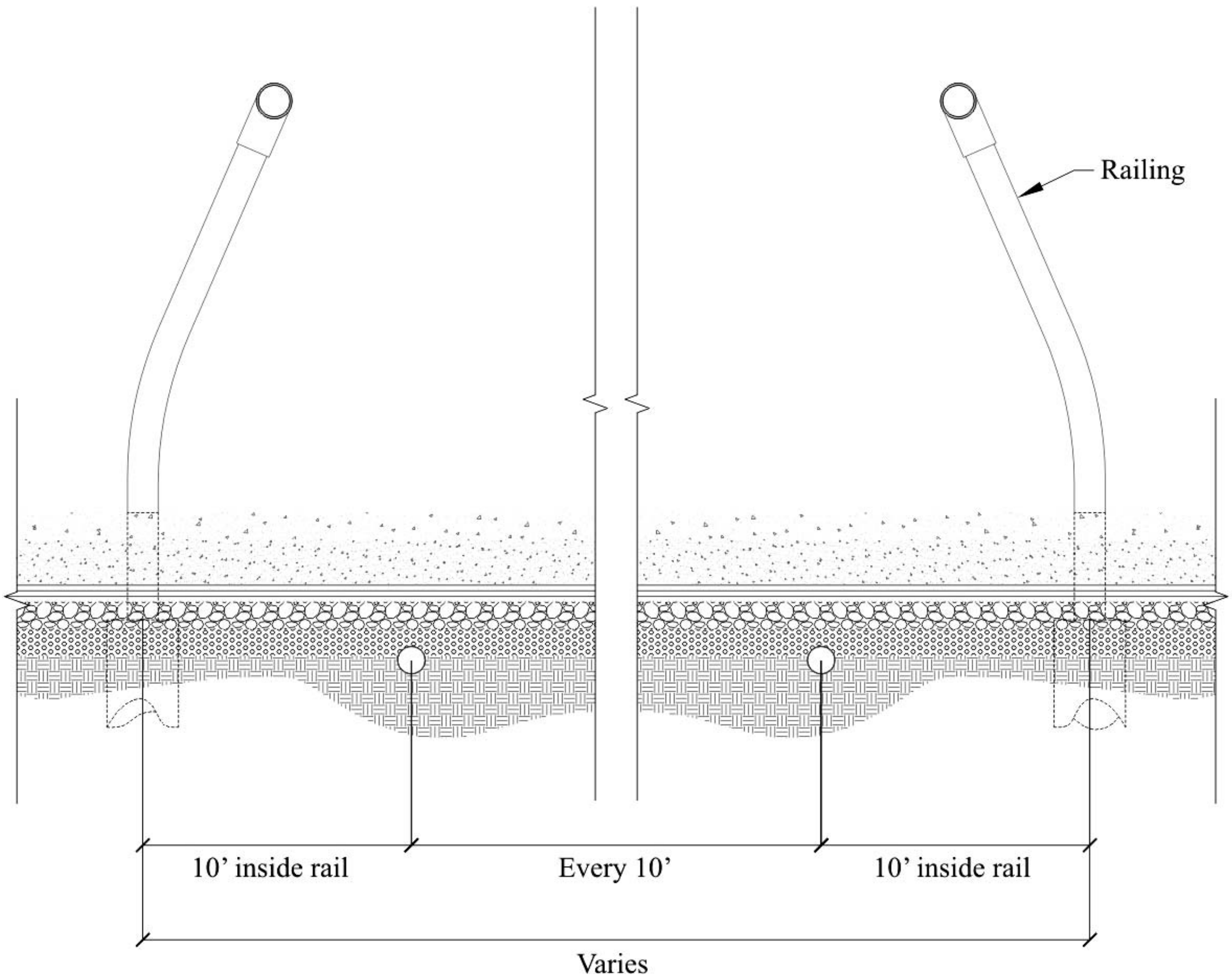


Figure 6-4. Synthetic profile at zero degrees.

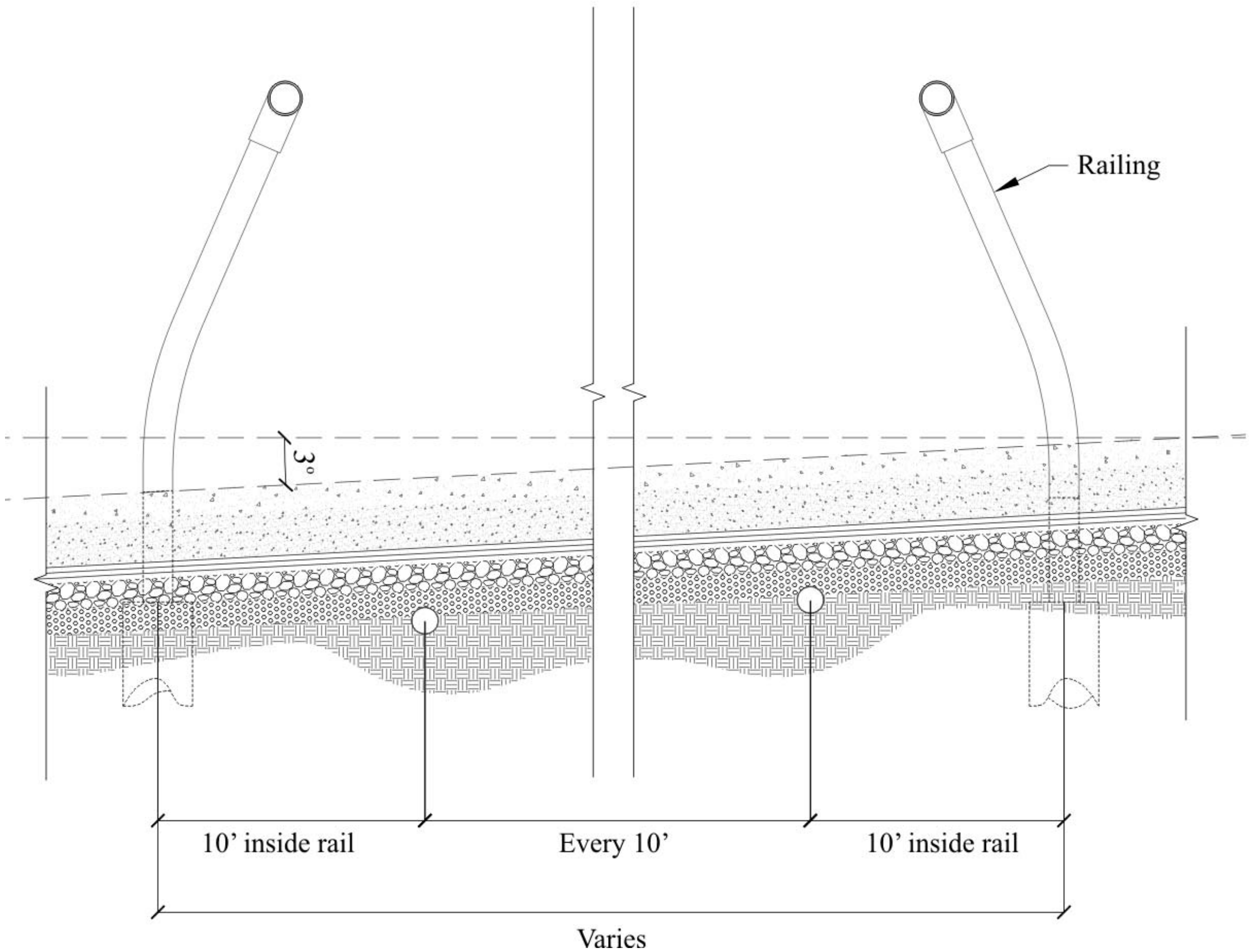


Figure 6-5. Synthetic profile at three degrees.

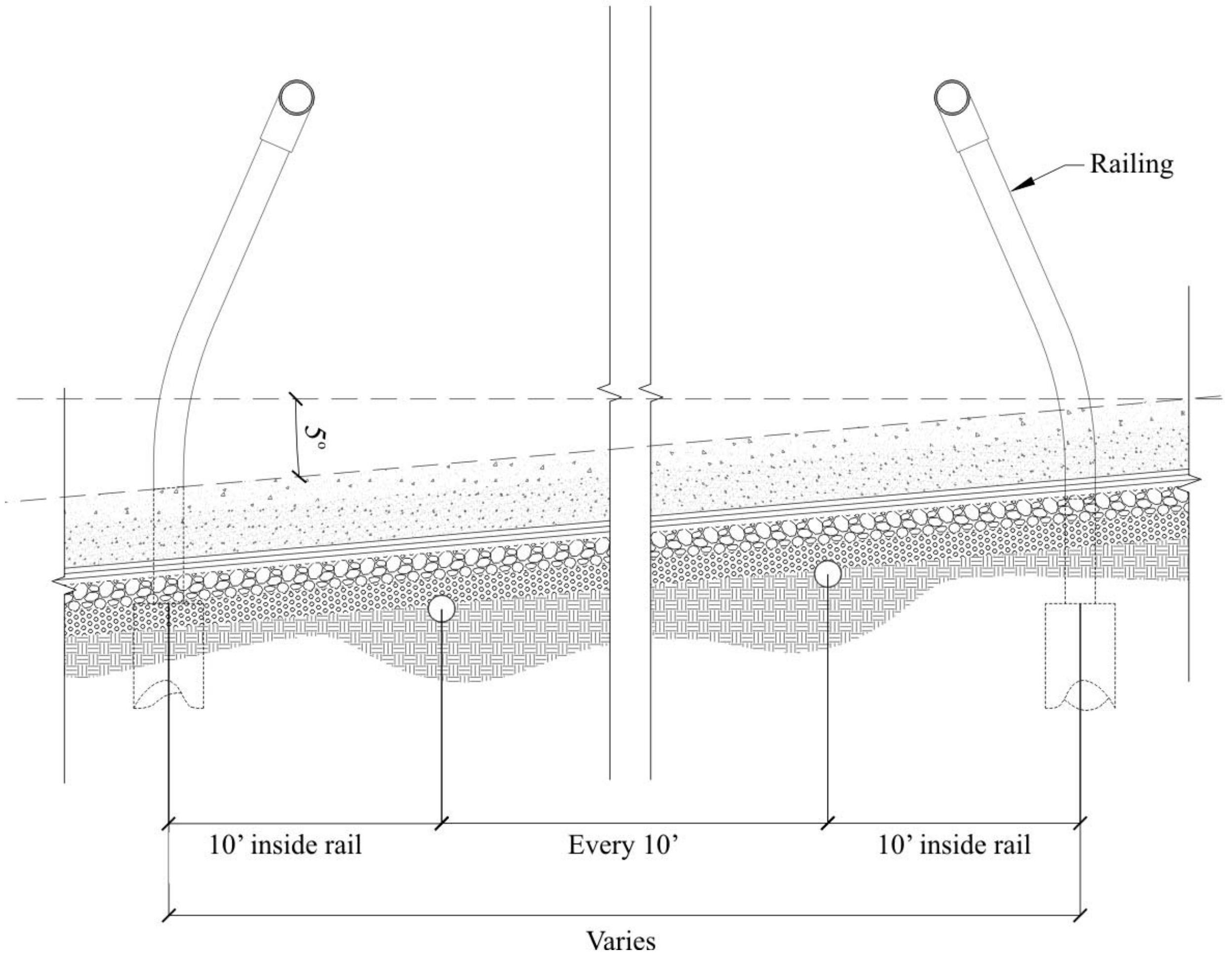


Figure 6-6. Synthetic profile at five degrees.

Figure 6-7. Maintenance equipment used for a synthetic surface. A) tractor, B) gallop master, C) power harrow, D) rotavator. (Source: www.polytrack.com).

CHAPTER 7
SURFACE MATERIAL ANALYSIS AND RESULTS

The conventional dirt and synthetic surface materials were analyzed for the properties relating to soil classification, soil compaction, and moisture content. The tests were conducted according to ASTM (American Society for Testing and Materials) standards, as these tests are often used throughout the general practice of construction. It is important to note that the same tests were attempted for both types of surface material, but not every test could be performed with the synthetic material. The conventional dirt surface material underwent testing to determine its maximum dry unit weight and optimum moisture content under compaction, its grain size distribution, and the liquid limit. Due to its composition, the synthetic surface material could only be tested to determine its maximum dry unit weight and optimum moisture content under compaction.

The two types of surface material that are referenced throughout this section were donated to conduct the following research. Approximately seven gallons of material consisting of two gallons of a conventional dirt surface and five gallons of a synthetic surface was donated. The performance of each material type was analyzed by conducting the following tests:

- ASTM D698-78 Standard Proctor Density Test. This is a standard compaction test that is performed to determine the optimum moisture content and maximum dry unit weight of soil.
- ASTM D422-63 Standard Test Method for Particle-Size Analysis of Soils. This is a test that is performed to determine the distribution of particle sizes throughout a given soil sample. This data is used to produce a grain size distribution curve allowing for the classification of soil.
- ASTM D423-66 Standard Test Method for Liquid Limit of Soils. This is a test that is performed using a liquid limit device to determine the liquid state of soil.

7.1 Conventional Dirt Surface Material Analysis

The following material analysis involved the testing of a conventional dirt surface mixture that was donated by a Thoroughbred training operation in Ocala, Florida. The sample is similar in quality to the material used by other operations throughout the area that also employ a conventional dirt surface for their racetrack. Although, it is important to note that variations do exist between the surfaces of one training operation versus another. The primary variations are due to the location of the racetrack with respect to environmental conditions, the quality and origination of local materials used in the surface mixture, and finally, the method(s) of maintenance provided to the surface.

7.1.1 Standard Proctor Density Test

This test was performed to determine the optimum moisture content that is needed during compaction for the soil to achieve its maximum strength. The maximum dry unit weight of the original sample was also determined from this test in addition to the relationship between soil density and moisture content. The experiment was repeated five times, with water being added at 75 mL increments each time. For each experiment, soil was compacted using a 5.5-pound hammer that was dropped from a height of 12 inches. During compaction, the mold was placed on a concrete floor surface while the blows were applied. From this series of tests, the wet unit weight of the in-place sample (Equation 7-1) and the dry unit weight of the in-place sample (Equation 7-2) were determined. See Table 7-1 and Table 7-2 for the lab data obtained during the experiment.

The objective of this test is to obtain the maximum dry unit weight of the soil, at which point there are zero voids. The water acts as a lubricant between the soil particles and acts to displace the air between the particles as the soil sample is being compacted. Once the water content exceeds what is necessary, the soil particles are displaced and the point of maximum density has been passed. The moisture content that is required to reach the maximum dry unit weight of the soil under a specific compaction is determined by the curve on the resulting graph. The moisture content known to yield the maximum density of the soil is referred to as the optimum moisture content. This is also the moisture content level where any additional amount of water will not allow a greater unit weight of the soil. The graph of this data produces a curve showing the relationship the moisture content versus the dry unit weight. See Figure 7-1 for a plot of the curve.

Wet Unit Weight of In-place Sample:

γ = [(weight of compacted soil and mold) – (weight of mold)]/(volume of mold) (7-1)

$\gamma = (13.01 \text{ lb} - 9.33 \text{ lb})/(1/30 \text{ ft}^3) = 110.4 \text{ lb/ft}^3$

Dry Unit Weight of In-place Sample:

$\gamma_d = \gamma/(1 + \text{moisture content, } w)$ (7-2)

$\gamma_d = 110.4 \text{ lb/ft}^3/(1 + 0.049) = 105.2 \text{ lb/ft}^3$

Results: The laboratory data allowed for a plot of a curve showing the relationship between the moisture content and the dry unit weight of the soil. From the graph, the maximum dry density was 106.4 lb/ft^3 with an optimum moisture content of 11.6%.

7.1.2 Liquid Limit of Soil

This test was performed using a device to determine the liquid limit of the soil according to the Atterberg definitions. It is also a test that is typically performed to determine the classification of soil according to AASHTO (American Association of State Highway and Transportation Officials) standards. For this study, the experiment was performed three times, with each run testing how many blows would close a 1/2” gap in a soil sample with an undetermined moisture content. The remaining soil from each run of the experiment was dried overnight in an oven to determine the water content of the soil. The relationship between the number of blows and water content of the soil is graphed as a series of points and results in a trendline that is referenced to determine the water content of the soil. See Table 7-3 for the lab data obtained during the experiment.

Results: From the plotted data points, the liquid limit of the soil at 25 blows is determined to be 20.55%. The measurement is taken where the trendline crosses 25 blows because this is known as the average point where the water content of the soil has reached its liquid limit. See Figure 7-2 for the graph of this experiment.

7.1.3 Plastic Limit of Soil

The plastic limit of the soil is made equal to zero, making this test not applicable to this study.

7.1.4 Particle-Size Analysis of Soil

This test was performed using a series of sieves to classify the soil according to ASTM and AASHTO standards. Before the test was conducted, a soil sample of approximately 600 grams was dried overnight in an oven to remove the in-place moisture. Once the test was completed, each sieve was weighed to determine the percentage of soil that passed. The percentage of soil passing the Number 40 sieve was used in the classification of the soil. The data obtained from this experiment was plotted on a grain size distribution chart to determine the soil classification. See Table 7-4 for the lab data obtained during the experiment and Figure 7-3 for a plot of the grain size distribution curve.

AASHTO Soil Classification:

LL (Liquid Limit) = 20.55%

PL (Plastic Limit) = 0%

PI (Plasticity Index) = LL – PL (7-3)

PI = 20.55% – 0% = 20.55%

Results: According to the AASHTO classification system, this soil is classified as A-2-6, Silty or Clayey Gravel and Sand.

ASTM Soil Classification:

Coefficient of Uniformity $C_u = D_{60}/D_{10}$ (7-4)

Coefficient of Curvature $C_c = (D_{30})^2/D_{60}D_{10}$ (7-5)

$D_{60} = 0.20$ mm

$D_{30} = 0.15$ mm

$D_{10} = 0.12$ mm

$C_u = 0.20$ mm/0.12 mm = 1.67

$C_c = (0.15 \text{ mm})^2/(0.20 \text{ mm} * 0.12 \text{ mm}) = 1.25$

Average Particle Size $D_{50} = 0.175$ mm

Results: According to the ASTM classification system, this soil is classified as SP, poorly graded sand.

7.2 Synthetic Surface Material Analysis

The following material analysis involved the testing of a synthetic surface mixture. A representative of Polytrack donated the material that was tested throughout the following experiments. The Polytrack surface, as well as other manufacturers' synthetic mixtures, are currently being used across the country by several racetracks that employ a synthetic surface. For these experiments, the synthetic surface is considered a mixture of organic and inorganic material consisting of a fine sand mixed with manmade components.

7.2.1 Standard Proctor Density Test

This test was performed to determine the optimum moisture content that is needed during compaction for the material to achieve its maximum strength. The maximum dry unit weight of the original sample was also determined from this test in addition to the relationship between soil density and moisture content. The experiment was repeated seven times, with water being added at 150 mL increments each time. For each experiment, the material was compacted using a 5.5-pound hammer that was dropped from a height of 12-inches. During compaction, the mold was placed on a concrete floor surface while the blows were applied. From this series of tests, the wet unit weight of the in-place sample (Equation 7-1) and the dry unit weight of the in-place sample (Equation 7-2) were determined. See Table 7-5 and Table 7-6 for the lab data obtained during the experiment.

Wet Unit Weight of In-place Sample:

$\gamma = (12.47\ \text{lb} - 9.33\ \text{lb})/(1/30\ \text{ft}^3) = 94.2\ \text{lb/ft}^3$

Dry Unit Weight of In-place Sample:

$\gamma_d = 94.2\ \text{lb/ft}^3/(1 + 0.099) = 85.7\ \text{lb/ft}^3$

Results: The laboratory data allowed for a plot of a curve showing the relationship between the moisture content and the dry density of the soil. From the graph, the maximum dry density was 96.75 lb/ft^3 with the optimum moisture content of 13.8%. See Figure 7-4 for the plot of the curve. See Figure 7-5 for a plot of the combined results from the conventional dirt and synthetic materials.

7.2.2 Liquid Limit of Soil

This test was not suitable for this type of surface material.

7.2.3 Plastic Limit of Soil

This test was not suitable for this type of surface material.

7.2.4 Particle-Size Analysis of Soil

This test was not suitable for this type of surface material.

Table 7-1. Water content determination of a conventional dirt surface material.

	Test 1	Test 2	Test 3	Test 4	Test 5
Weight of wet soil and container	129.2 g	184.5 g	193.2 g	208.2 g	227.6 g
Weight of dry soil and container	125.5 g	173.8 g	177.8 g	188.3 g	201.9 g
Weight of water	3.7 g	10.7 g	15.4 g	19.9 g	25.7 g
Tare weight of container	50.4 g	50.0 g	50.1 g	49.8 g	50.2 g
Weight of dry soil	75.1 g	123.8 g	127.7 g	138.5 g	151.7 g
Water content[1]	4.93%	8.64%	12.06%	14.37%	16.94%

[1]Water content = (weight of water/weight of dry soil) x 100

Table 7-2. Standard proctor density test to determine optimum moisture content of a conventional dirt surface material.

	Test 1	Test 2	Test 3	Test 4	Test 5
Weight of mold and compacted soil, W_1	13.01 lb	13.15 lb	13.30 lb	13.26 lb	13.23 lb
Weight of mold, W_2	9.33 lb	9.33 lb	9.33 lb	9.33 lb	9.33 lb
Weight of compacted soil, W_3[1]	3.68 lb	3.82 lb	3.97 lb	3.93 lb	3.90 lb
Wet density of soil, D_1[2]	110.40 lb/ft^3	114.60 lb/ft^3	119.10 lb/ft^3	117.90 lb/ft^3	117.00 lb/ft^3
Water content (from above), w	0.049	0.086	0.121	0.144	0.169
Dry density of soil, D_2[3]	105.22 lb/ft^3	105.48 lb/ft^3	106.28 lb/ft^3	103.09 lb/ft^3	100.05 lb/ft^3

[1]$W_3 = (W_1 - W_2)$
[2]$D_1 = W_3 \times 30$ lb/ft^2
[3]$D_2 = D_1/(1 + w)$

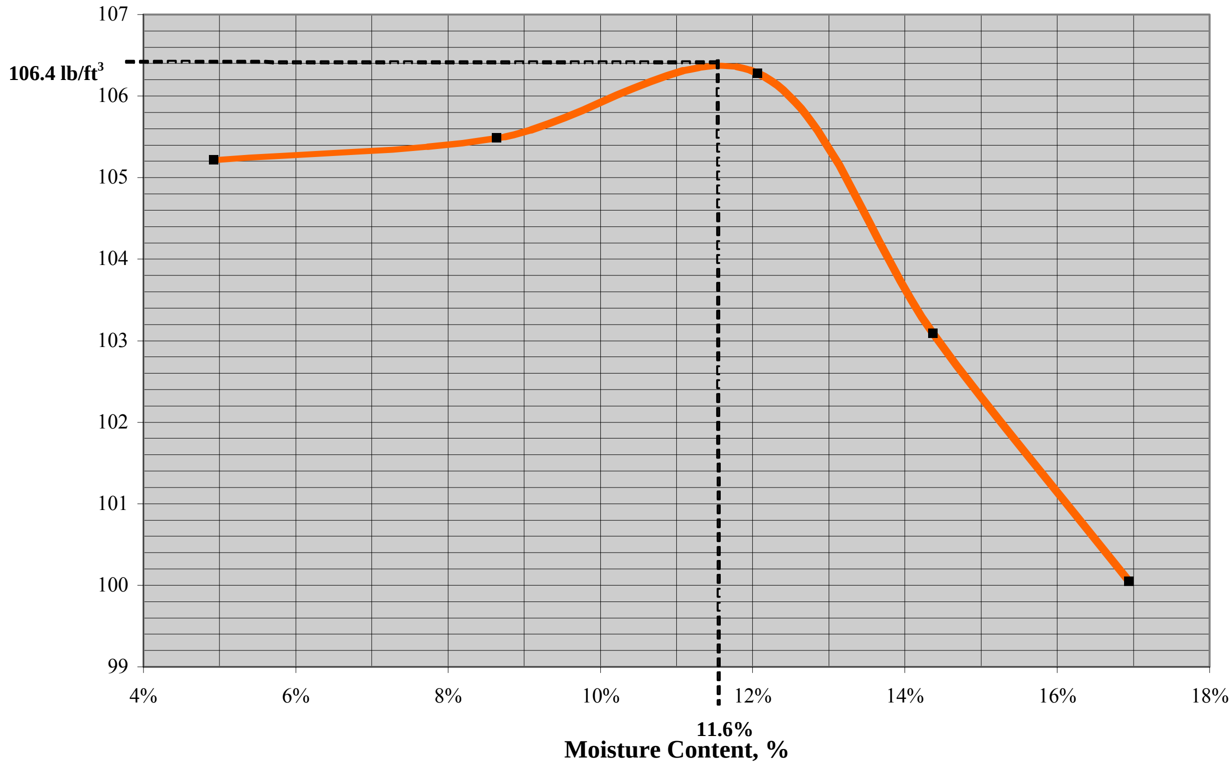


Figure 7-1. Proctor curve for conventional dirt surface material.

Table 7-3. Atterberg limit test of a conventional dirt surface material.

Test number	1	2	3
Number of blows	31	18	33
Container number	4C2	5C1	5C2
Weight of wet soil and container, W_1	231.5 g	216.1 g	227.4 g
Tare weight of container, W_2	50.0 g	50.3 g	50.4 g
Weight of wet soil, W_3[1]	181.5 g	165.8 g	177.0 g
Weight of dry soil and container, W_4	201.5 g	187.2 g	197.6 g
Weight of dry soil, W_5[2]	151.5 g	136.9 g	147.2 g
Weight of water, W_6[3]	30.0 g	28.9 g	29.8 g
Water content, w[4]	19.80%	21.11%	20.24%

[1] $W_3 = (W_1 - W_2)$

[2] $W_5 = (W_4 - W_2)$

[3] $W_6 = (W_3 - W_5)$

[4] $w = (W_6 / W_5) \times 100$

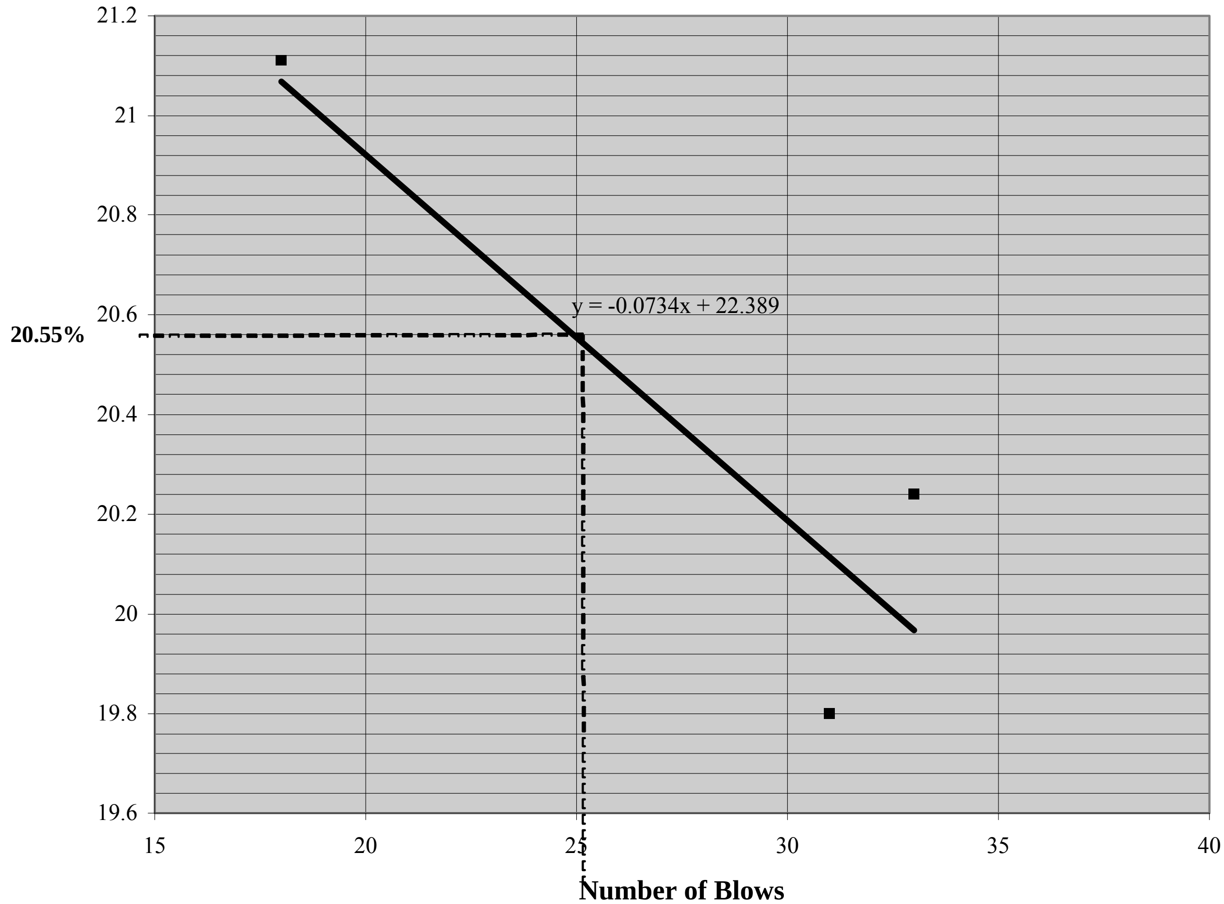


Figure 7-2. Water content determination at 25 blows for a conventional dirt surface material.

Table 7-4. Sieve analysis of a conventional dirt surface material.

Sieve number	Weight of sieve and soil, W_1	Weight of sieve, W_2	Weight of soil retained, W_3[1]	Percentage retained, P_1[2]	Cumulative percent retained, P_2[3]	Percent passing, P_3[4]
4	593.0 g	592.0 g	1.0 g	0.10%	0.10%	99.90%
10	495.0 g	494.0 g	1.0 g	0.10%	0.21%	99.79%
20	572.0 g	571.0 g	1.0 g	0.10%	0.31%	99.69%
40	357.0 g	349.0 g	8.0 g	0.83%	1.15%	98.85%
60	688.0 g	480.0 g	208.0 g	21.67%	22.81%	77.19%
140	1009.0 g	298.0 g	711.0 g	74.06%	96.88%	3.13%
200	310.0 g	290.0 g	20.0 g	2.08%	98.96%	1.04%
Pan	528.0 g	518.0 g	10.0 g	1.04%	100.00%	0.00%
Totals	4552.0 g	3592.0 g	960.0 g	100.00%	320.42%	

[1] $W_3 = (W_1 - W_2)$

[2] $P_1 = (W_3/\text{initial weight of soil}) \times 100$

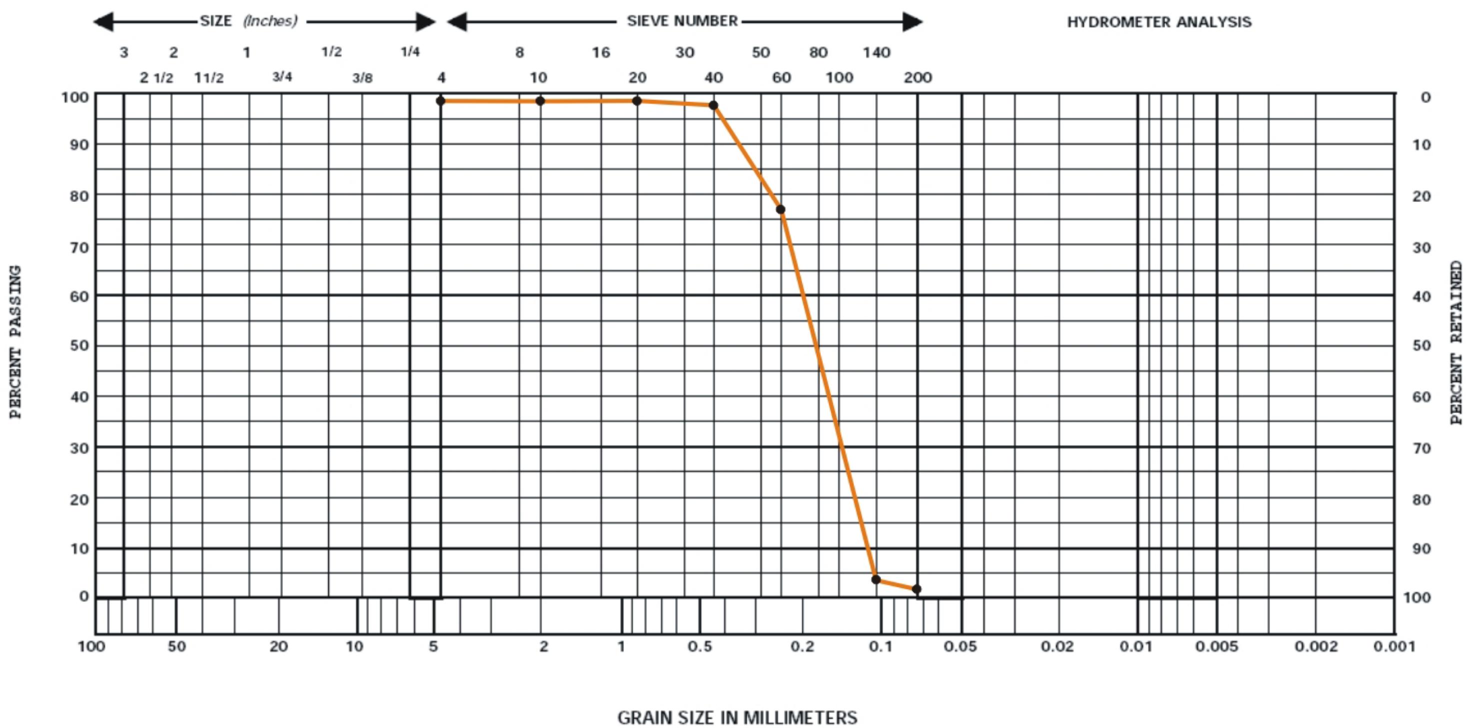
[3] $P_2 = P_2 + \text{previous } P$

[4] $P_3 = 100 - P_2$

GRAIN SIZE DISTRIBUTION GRAPH - AGGREGATE GRADATION CHART

1. PROJECT	2. DATE

SIEVE ANALYSIS - US STANDARD SIEVE SIZES



EXCAVATION NUMBER	SAMPLE NUMBER	LL	PL	PI	Cu (D_{60}/D_{10})	Cc $(D_{30})^2/(D_{60} \times D_{10})$	SOIL DESCRIPTION/REMARKS	CLASSIFICATION (USCS)

3. TECHNICIAN *(Signature)*	4. PLOTTED BY *(Signature)*	5. CHECKED BY *(Signature)*

Figure 7-3. Grain size distribution curve for a conventional dirt surface material.

Table 7-5. Water content determination of a synthetic surface material.

	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Test 7
Weight of wet soil and container	135.7 g	143.1 g	129.3 g	124.2 g	136.2 g	145.8 g	139.7 g
Weight of dry soil and container	135.4 g	139.3 g	123.1 g	116.9 g	125.2 g	130.7 g	122.7 g
Weight of water	0.3 g	3.8 g	6.2 g	7.3 g	11.0 g	15.1 g	17.0 g
Tare weight of container	50.4 g	49.9 g	50.1 g	49.8 g	50.2 g	49.9 g	50.3 g
Weight of dry soil	85.0 g	89.4 g	73.0 g	67.1 g	75.0 g	80.8 g	72.4 g
Water content[1]	0.35%	4.25%	8.49%	10.88%	14.67%	18.69%	23.48%

[1]Water content = (weight of water/weight of dry soil) x 100

Table 7-6. Standard proctor density test to determine optimum moisture content of a synthetic surface material.

	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Test 7
Weight of mold and compacted soil, W_1	12.47 lb	12.61 lb	12.71 lb	12.88 lb	13.02 lb	13.04 lb	13.03 lb
Weight of mold, W_2	9.33 lb	9.33 lb	9.33 lb	9.33 lb	9.33 lb	9.33 lb	9.33 lb
Weight of compacted soil, W_3[1]	3.14 lb	3.28 lb	3.38 lb	3.55 lb	3.69 lb	3.71 lb	3.70 lb
Wet density of soil, D_1[2]	94.20 lb/ft^3	98.40 lb/ft^3	101.40 lb/ft^3	106.50 lb/ft^3	110.70 lb/ft^3	111.30 lb/ft^3	111.00 lb/ft^3
Water content (from above), w	0.004	0.043	0.085	0.109	0.147	0.187	0.235
Dry density of soil, D_2[3]	85.71 lb/ft^3	89.88 lb/ft^3	92.86 lb/ft^3	97.92 lb/ft^3	102.10 lb/ft^3	102.69 lb/ft^3	102.39 lb/ft^3

[1]$W_3 = (W_1 - W_2)$
[2]$D_1 = W_3 \times 30\ lb/ft^2$
[3]$D_2 = D_1/(1 + w)$

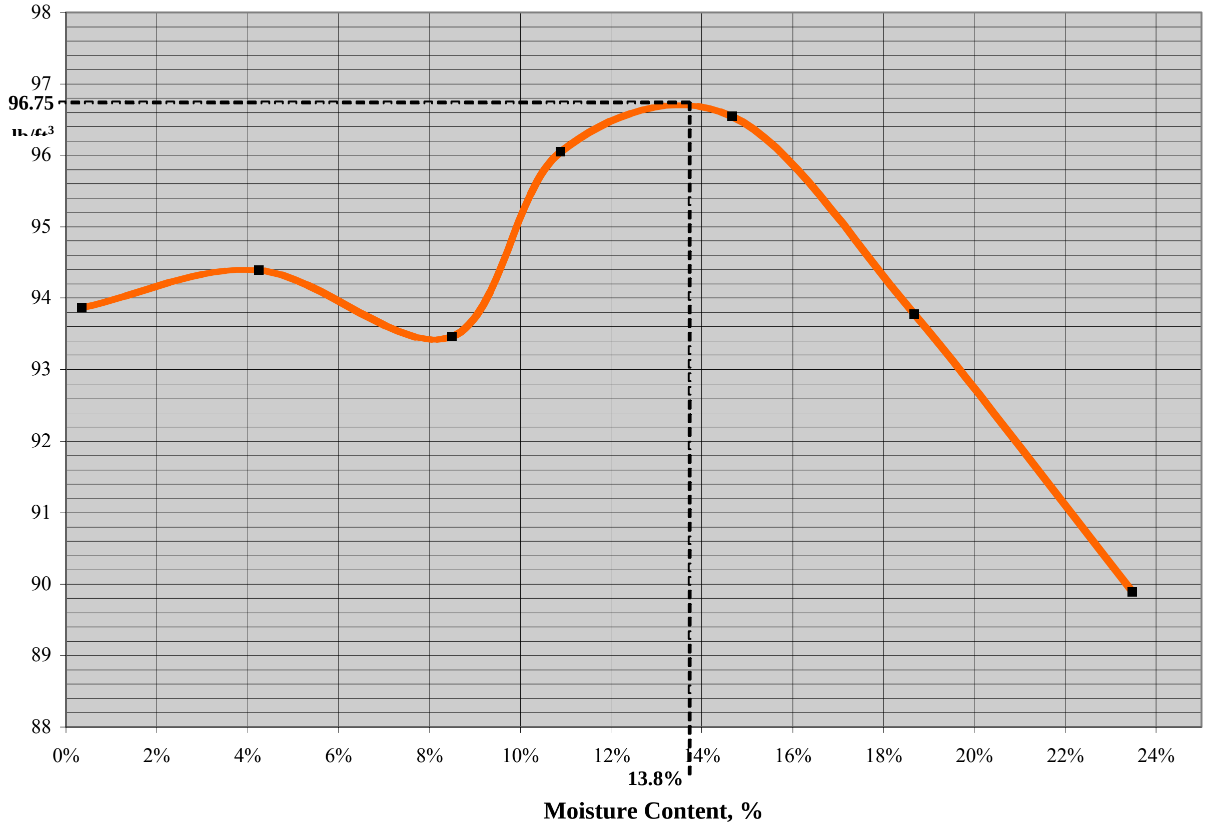


Figure 7-4. Proctor curve for synthetic surface material.

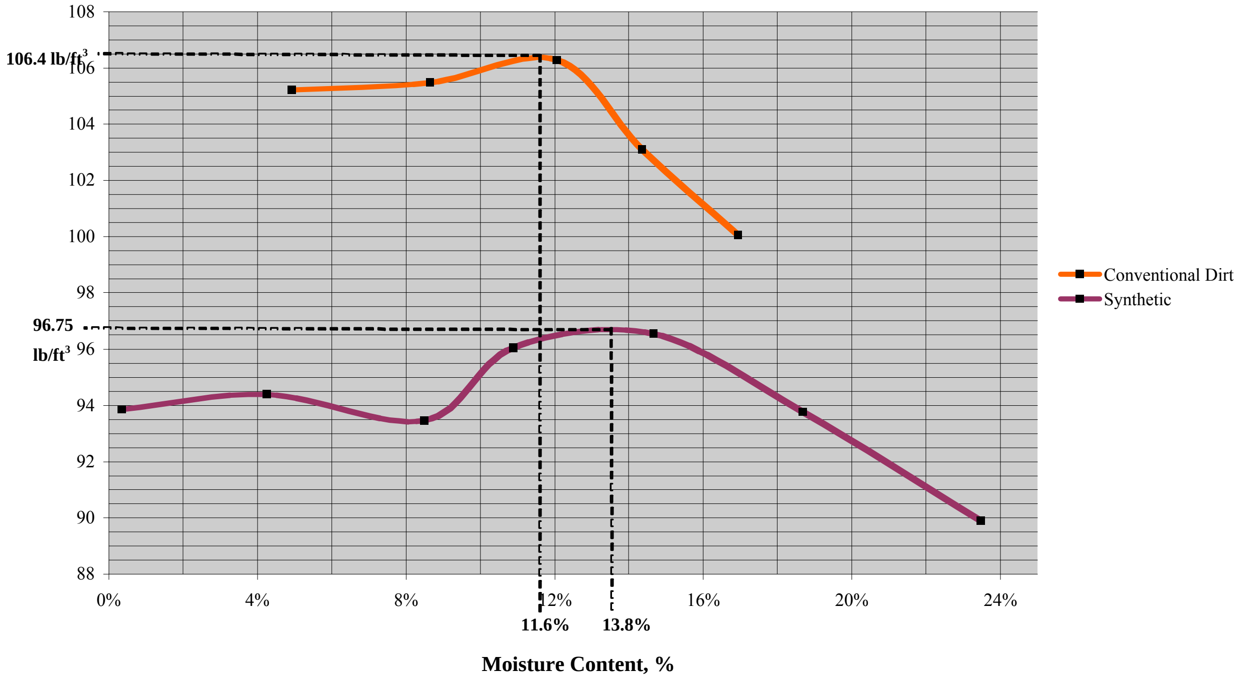


Figure 7-5. Combined proctor curve of conventional dirt and synthetic surface materials.

CHAPTER 8
STATISTICAL THOROUGHBRED HORSE RACING RESULTS

The information in the following data was obtained from a synthetic manufacturer to determine the statistical results of the catastrophic injury rates of racehorses. The data was obtained before and after the installation of a Polytrack synthetic surface. The data represents the number of race days per season for the racetrack listed, the average number of starters per race, the number catastrophic breakdowns in the mornings and afternoons, and the number of horses worked over the surface during the meet. Table 8-1 represents data before the installation of the synthetic surface. Tables 8-2 and 8-3 represent the results one and two years following the installation of the synthetic surface, respectively.

The various racetrack facilities referenced in the data are located across the United States and Canada: Arlington Park racetrack is located in Arlington Heights, Illinois. Del Mar racetrack is located in Del Mar, California. Keeneland racetrack is located in Lexington, Kentucky. Turfway Park racetrack is located in Florence, Kentucky. Woodbine racetrack is located in Toronto, Ontario, Canada.

Table 8-1. Pre-Polytrack statistical results

Racetrack	Race days	Average number of starters per race	Catastrophic breakdowns on main track (pm)	Catastrophic breakdowns during training (am)	Number of workouts on main track during meet
Arlington Park	95	7.14	22	7	11,142
Del Mar	43	8.57	8	6	6,500
Keeneland	17	9.14	2	0	1,304
Turfway Park	74	9.04[1]	18	N/A	1,645
Woodbine	43	7.97	2	N/A	3,196

Source: www.polytrack.com
[1]Average between the Winter, Spring, Fall, and Holiday meets.

Table 8-2. Post-Polytrack statistical results (first year after installation)

Racetrack	Race days	Average number of starters per race	Catastrophic breakdowns on main track (pm)	Catastrophic breakdowns during training (am)	Number of workouts on main track during meet
Arlington Park	94	8.19	13	7	14,268
Del Mar	43	8.82	2	4	7,422
Keeneland	32	9.00[1]	3	0	1,930
Turfway Park	116	9.17[2]	7	2	5,372
Woodbine	43	8.78	3	N/A	6,557

Source: www.polytrack.com
[1]Average between the Fall and Spring meets.
[2]Average between the Winter, Spring, Fall, and Holiday meets.

Table 8-2. Post-Polytrack statistical results (second year after installation)

Racetrack	Race days	Average number of starters per race	Catastrophic breakdowns on main track (pm)	Catastrophic breakdowns during training (am)	Number of workouts on main track during meet
Arlington Park	96	7.14	22	7	14,812
Del Mar	43	8.75	5	3	7,496
Keeneland	32	9.83[1]	4	0	3,406
Turfway Park	109	9.15[2]	11	4	4,396
Woodbine	44	8.67	2	N/A	4,669

Source: www.polytrack.com
[1]Average between the Fall and Spring meets.
[2]Average between the Winter, Spring, Fall, and Holiday meets.

CHAPTER 9
CONCLUSIONS AND RECOMMENDATIONS

9.1 Conclusions

The following is a set of conclusions that have been drawn according to the information and data collected throughout the execution of this study. The conclusions will discuss the survey results of the Thoroughbred facilities located in Ocala, Florida in addition to the findings from the interviews with California racetrack superintendents. Also discussed are the differences in constructing and retrofitting the two different surfaces and the results of the material analysis. These conclusions were made in an effort to better understand where the industry stands in terms of implementing synthetic surfaces into the training and racing of horses.

9.1.1 Survey Results

It can be concluded from the results of the Ocala survey that the majority of facilities are still training horses over a conventional dirt surface. It is also determined that the facilities surveyed prefer a natural surface to an artificial one. Perhaps the hesitation to convert is due to the physical and statistical costs associated with synthetic surfaces. This situation may change as time passes and more information becomes available about the use and effects of synthetic surfaces on the training of horses.

Although the majority of facilities surveyed prefer conventional dirt to synthetic, it was found that maintenance is performed once, twice, and sometimes three times per day. It was also found that moisture is managed by artificial methods. From this study, it is known that the costs to maintain a conventional dirt surface are much higher than those for a synthetic surface. On an annual basis, maintenance costs do accumulate and a facility will spend a significant amount of money to adequately maintain their surface. Therefore, it can be concluded that these facilities operate the bulk of each day through manpower to run equipment and condition material that is only used approximately four to five hours per day for training horses.

From the survey, it can be understood that the amount of injuries experienced by horses trained over conventional dirt surfaces remain fairly low, with the most common type being bucked shins. The average age of a racehorse in training is two years old and it is known that injuries do occur in young horses performing at high speeds. With these findings, it can be concluded that the type of surface that a young horse is being trained over may not have a considerable effect on the occurrence or type of injuries they experience.

Following an order mandated by the California Horse Racing Board, the four major Thoroughbred racetrack facilities in the state of California were forced to install a synthetic surface by 2008. After one year, the racetrack superintendents have offered feedback about the successes, failures, and anticipated life cycle of the surface at their respective facility. As a whole, the satisfactory aspects of the surfaces involve less maintenance with regard to man-hours and the amount of water required to maintain moisture. The unexpected issues with the synthetic surfaces involve their sensitivity and failure to perform in the environment in which they are placed, resulting in replacing one manufacturer's product with another. The anticipated life cycle of the synthetic surfaces in California is unknown at the current time. However, the top cushion of an intensely used surface is known to need a reapplication, or refurbishing, of the wax coating approximately every six months. It can be concluded that California is a testing ground for synthetic surfaces in this country and the findings of how these surfaces are performing under the present conditions will be useful in the future.

9.1.2 Installation and Retrofit

The construction of a synthetic surface is costly in terms of its physical assembly as well as its effects on the Thoroughbred horse racing industry. The majority of synthetic surfaces that exist in the United States have replaced an existing conventional dirt surface. Not only does this involve the demolition of an existing racetrack but also the complete installation of a more sophisticated system. This consideration also comes at a cost to the horses themselves, as they are the ones ultimately testing the surface through their athletic ability. Furthermore, the installation or retrofit of a synthetic surface may be more appropriate for some racetrack locations than others, particularly with regard to the environment and intensity of use. From these findings, it can be concluded that the installation or retrofit of a conventional dirt surface with a synthetic surface should be carefully considered before it is executed.

9.1.3 Material Analysis

The laboratory results from the analysis performed with the conventional dirt and synthetic materials confirmed that they react very differently under the same conditions. Under the standard proctor test for compaction, the conventional dirt mixture reached its maximum dry density sooner and under a lower moisture content than the synthetic material. Alternatively, the synthetic mixture required two additional proctor tests to reach its maximum dry density under a higher moisture content than the conventional dirt mixture. It can be concluded from this comparison that the synthetic mixture manages moisture better than the conventional dirt. It is important to note that the synthetic mixture is a unique material that could not be appropriately tested under the other standard soil tests that were performed with the conventional dirt.

9.2 Recommendations

As this study was primarily focused on evaluating two different racetrack surfaces, it has only scratched the surface for the how they may be further studied and improved to better serve the Thoroughbred horse racing industry. The introduction of synthetic surfaces to the industry has created new challenges that were not present prior to their use. Before they were implemented, the industry was consistently faced with the loss of racing days to inclement weather, the increased occurrence of catastrophic breakdowns, and the strenuous time and labor required to maintain an acceptable surface. In response to these issues, synthetic surfaces have somewhat provided relief for the industry but have also introduced a new set of issues relating to materiality, construction, and performance for the task of racing horses. It is recommended that this study be further evaluated through the disciplines of veterinary science, engineering, and building construction to better understand how the two surfaces affect a horse's body through their design and physical assembly.

In relation to veterinary science, it is recommended that both types of surfaces be further evaluated for their effects on the body of a racehorse. It is known that both types of surfaces can cause injury, even catastrophic breakdown, of a racehorse. It has been discovered that a conventional dirt surface is more likely to affect the skeletal structure of a racehorse, whereas a synthetic surface is known to affect the soft and deep tissue of a racehorse. It is recommended that the injuries associated with these areas of a horse's body be evaluated for their nature so they may be linked to how they occur over a given type of surface.

If this study was taken into the engineering field, it is recommended that the two surface materials be further evaluated for the properties relating to cushion and compaction under the forces produced by a racehorse. It is also recommended that these forces be evaluated for how they transcend through muscles and joints of a racehorse. These findings could be used to determine how each type of surface may be less strenuous on the body of a racehorse while still allowing them to perform at top speed.

For building construction, this study could be further evaluated through cost estimating and sustainability. It is known that the initial cost of replacing a conventional dirt surface with a synthetic one is offset by its low-maintenance qualities. It is recommended that the estimated cost of installation for a synthetic surface be studied and compared to conventional dirt through time-analyzed data as it relates to maintenance. This could potentially lead to additional improvements in materiality and the overall design of the system, inherently affecting the health and performance of racehorses. With regard to sustainability, it is recommended that the life cycle assessment of both surfaces be performed to determine their effect on the environment. Although a conventional dirt surface is less complex in material composition, a synthetic surface consists of various components that could easily be used as an additional stage in the life cycle of a product.

APPENDIX A
LIST OF TERMINOLOGY AND ABBREVIATIONS

- Bowed tendon. An injury to the superficial digital flexor tendon in the front leg of a horse that when damaged, results in a thickening of the tendon, making it appear bowed when viewed from the side.

- Bucked shin. An injury that commonly occurs in younger horses that are performing at high speeds. It occurs when the tissue attaching the muscle to the cannon bone in the front leg is torn from the bone.

- Catastrophic. In Thoroughbred horse racing, this is the term used for a traumatic, fatal injury.

- CHRB. California Horse Racing Board.

- Classic. Used to refer to traditionally significant races, such as the Breeders' Cup. In America, the classic distance is 1-1/4 miles and in Europe it is 1-1/2 miles.

- Claim Race. A race in which the horses are eligible to be entered and can be claimed for a set price.

- Cup. A race for Thoroughbreds three-years-old and up.

- Derby. A stakes race for three-year-olds.

- Elastic fibers. These are the fibers found in a synthetic surface that consist of chopped elastic bands.

- Handicap. A race for which each horse is assigned a different weight to carry with the concept that the horses run a fair and equal race.

- Handle. An amount of money that is wagered in a pari-mutuel bet on a race.

- Juvenile. A two-year-old horse.

- NTRA. National Thoroughbred Racing Association.

- Operation. A training facility.

- Pari-mutuel. A form of betting where money is put into wagering pools, where betters play against one another.

- Splint. An injury that occurs in the front leg of a horse when the ligament attaching the splint and cannon bones together is torn. It is often the result of concussion trauma that is common to the sport of Thoroughbred horse racing.

- Sprint. A race that is less than one mile in length.

- Stakes race. A race for which the owner must pay to race their horse, unless the race is by invitation and does not require a fee.

- Suspensory. An injury that typically occurs when a horse is moving at a high speed and begins to fatigue. It affects the suspensory ligament, which is critical to the support system of the lower region of a horse's front leg. This type of injury may occur at any point along the ligament, which can dramatically affect the racing career of the horse.

- Thoroughbred. The most common breed of racehorse.

- TOBA. Thoroughbred Owners and Breeders Association.

APPENDIX B
LIST OF THOROUGHBRED HORSE RACES IN THE UNITED STATES

Table B-1. List of Thoroughbred horse races in the United States.

Name	Racetrack	Location	Year Inaug.	F	C	Length	Purse	Surface
American Oaks	Hollywood Park	Inglewood, CA	2002	X		1 1/4 mile	$750,000	Turf
Arlington Million	Arlington Park	Arlington Heights, IL	1981	X	X	1 1/4 mile	$1,000,000	Turf
Belmont Stakes*	Belmont Park	Elmont, NY	1867	X	X	1 1/2 mile	$1,000,000	Dirt
Blue grass Stakes	Keeneland Race Course	Lexington, KY	1911	X	X	1 1/8 mile	$750,000	Polytrack
Breeders' Cup Juvenile Fillies Turf			2008	X		1 mile	$1,000,000	Turf
Breeders' Cup Filly & Mare Sprint			2007	X		7/8 mile	$1,000,000	Dirt**
Breeders' Cup Juvenile Fillies			1984	X		1 1/16 mile	$2,000,000	Dirt**
Breeders' Cup Filly & Mare Turf			1999	X		1 1/4 mile	$2,000,000	Turf
Breeders' Cup Ladies' Classic			2007	X		1 1/8 mile	$2,000,000	Dirt**
Breeders' Cup Marathon			2008	X	X	1 1/2 mile	$500,000	Dirt**
Breeders' Cup Juvenile Turf			2007	X		1 mile	$1,000,000	Turf
Breeders' Cup Dirt Mile			2007	X	X	1 mile	$1,000,000	Dirt**

Table B-1. Continued.

Breeders' Cup Turf Sprint			2008	X	X	13/16 mile	$1,000,000	Turf
Breeders' Cup Juvenile			1984		X	1 1/16 mile	$2,000,000	Dirt**
Breeders' Cup Sprint			1984	X	X	3/4 mile	$2,000,000	Dirt**
Breeders' Cup Mile			1984	X	X	1 mile	$2,000,000	Turf
Breeders' Cup Turf			1984	X	X	1 1/2 mile	$3,000,000	Turf
Breeders' Cup Classic			1984	X	X	1 1/4 mile	$5,000,000	Dirt**
Donn Handicap	Gulfstream Park	Hallandale Beach, FL	1981	X	X	1 1/8 mile	$500,000	Dirt
Florida Derby	Gulfstream Park	Hallandale Beach, FL	1952	X	X	1 1/8 mile	$1,000,000	Dirt
Hollywood Gold Cup	Hollywood Park	Inglewood, CA	1938	X	X	1 1/4 mile	$750,000	Dirt
Jim Dandy Stakes	Saratoga Race Course	Saratoga Springs, NY	1964	X	X	1 1/8 mile	$500,000	Dirt
Jockey Club Gold Cup	Belmont Park	Elmont, NY	1919	X	X	1 1/4 mile	$1,000,000	Dirt
Kentucky Derby*	Churchill Downs	Louisville, KY	1875	X	X	1 1/4 mile	$2,000,000	Dirt
Kentucky Oaks	Churchill Downs	Louisville, KY	1875	X		1 1/8 mile	$500,000	Dirt
Louisiana Derby	Fair Grounds Race Course	New Orleans, LA	1898	X	X	1 1/16 mile	$600,000	Dirt
Manhattan Handicap	Belmont Park	Elmont, NY	1896	X	X	1 1/4 mile	$400,000	Turf
Pacific Classic Stakes	Del Mar Racetrack	Del Mar, CA	1991	X	X	1 1/4 mile	$1,000,000	Polytrack
Pimlico Special	Pimlico Race Course	Baltimore, MD	1937	X	X	1 3/16 mile	$250,000	Dirt

Table B-1. Continued.

Preakness Stakes*	Pimlico Race Course	Baltimore, MD	1873	X	X	1 3/16 mile	$1,000,000	Dirt
Santa Anita Handicap	Santa Anita Park	Arcadia, CA	1935	X	X	1 1/4 mile	$1,000,000	Cushion Track
Santa Anita Derby	Santa Anita Park	Arcadia, CA	1935	X	X	1 1/8 mile	$750,000	Cushion Track
Travers Stakes	Saratoga Race Course	Saratoga Springs, NY	1864	X	X	1 1/4 mile	$1,000,000	Dirt
Whitney Handicap	Saratoga Race Course	Saratoga Springs, NY	1928	X	X	1 1/8 mile	$750,000	Dirt
Wood Memorial Stakes	Aqueduct Racetrack	Queens, NY	1925	X	X	1 1/8 mile	$750,000	Dirt
Woodward Stakes	Saratoga Race Course	Saratoga Springs, NY	1954	X	X	1 1/8 mile	$500,000	Dirt

*Part of Triple Crown series

**Depending on host track, this race may be over a synthetic surface

APPENDIX C
COLLECTION OF SURVEY DATA

The following is a survey that was sent in the form of a questionnaire to approximately 265 Thoroughbred racing operations located in Ocala, Florida. See Appendix E for the list of training and racing operations where the surveys were mailed. The operations targeted for the survey included those that participate in the equine racing discipline only and were randomly chosen regardless of the size of the training facility, the number of horses in training, or how intensely the racetrack was being used.

1. What is the primary surface material of your racetrack?
______Dirt/Soil
______Turf
______You have both a dirt and turf track
______Synthetic

2. Of the materials listed above, would you prefer the *natural* or *synthetic* product?

3. If your racetrack consists of a *natural* product, are you familiar with where it originated from?
______Yes
______No
If yes, please briefly explain the type (eg. sand base, clay base, or both):

4. If your racetrack consists of a *synthetic* product, are you familiar with the manufacturer and the process of how the product was made?
______Yes
______No
If yes, please briefly explain:

5. What is the typical maintenance schedule for your racetrack?
______Daily
______Once daily
______Twice daily
______Weekly
______Once weekly
______Twice weekly
______Three times weekly
______Monthly
______Once monthly
______Twice monthly
______Three times monthly

______Other
What type of maintenance is performed?

6. How is an acceptable level of moisture managed for your racetrack? How is it measured or determined?

7. What is the measured length of your racetrack?

8. Is your racetrack mostly a flat surface, banked surface, or a combination of both?

9. How often is your racetrack used on a daily, weekly, and monthly basis?
______Daily
______Weekly
______Monthly

10. What is your racetrack primarily used for?
______Training
______Competition
______Both

11. What is the average age of the horse(s) that are run on your racetrack?

12. What are the most common type(s) of injuries that the horse(s) experience while running on your racetrack?

13. Where is the location on your racetrack where the injuries most commonly occur?

14. If there is anything you would like to change about the design of your racetrack, what would it be?

15. Any other comments:

APPENDIX D
LIST OF QUESTIONS FOR CALIFORNIA RACETRACKS

The following is a series of questions that were posed to the racetracks in California that currently employ a synthetic surface. The racetrack superintendents were asked these questions and answered them to the best of their knowledge:

1. How much did the synthetic surface cost to install?

2. How was the racetrack surface constructed before the synthetic surface was installed?

3. Were any of the sub-base layers of the original surface retained in the construction of the synthetic surface? If so, which layers?

4. What was the average annual cost of maintenance for the conventional dirt surface at your facility?

5. What is the average annual cost of maintenance for the synthetic surface at your facility?

6. How many horses are worked over the synthetic surface at your facility on a daily basis?

7. What is the expected life cycle of the synthetic surface at your facility?

APPENDIX E
LIST OF HORSE RACING FARMS LOCATED IN OCALA, FLORIDA

Table E-1. List of horse racing farms located in Ocala, Florida.

Farm name	Size (acres)	Dirt track	Length (miles)	Turf track	Length (miles)	Synthetic track	Length (miles)
Abbie Road Farm	15	X	1/2				
Abracadabra Farms	212	X	3/4	X	5/8		
Adena Springs South	4,500	X	1				
AGB Stables	77	X	3/4				
Diane Allen, agent	10	X	3/4				
American Equistock, Inc.	40	X	5/8				
Andros Farms	125	X	3/8	X	3/4		
Another Episode Farm	78	X	5/8				
Anthony Perri Farm	23	X	1/2				
Antigo Ranch	65	X	1/2				
Arindel	470	X					
Balmoral Bloodstock, Inc.		X	5/8				
Bar-Lyn Farm	15	X	3/8				
Best A Luck Farm	45	X	5/8				
Biamonte Training Center	40	X	5/8				
Big “C” Farm	240	X	1/2				
Bit of Class Training Stable	15	X	1/2				
Bittersweet Acres	27	X	1/2				
Black Diamond	16	X	3/8				
Bolaro Farm	160	X	5/8				
Lynne and Chris Boutte Training Stable	35	X	5/8	X	1/2		
Briar Lane Farm	35	X	1/2				
Bridlewood Farm	960	X	7/8	X	1		
Buckley Farm	41	X	1/2				
Camelot Acres	100	X	5/8				
Can 2 Farm	20	X	1/2				
Cardinal Hill Farm	170	X	5/8				
Cashel Stud, Inc.	500	X	5/8				
Cedar Lock Farm South	65	X	1/2				
Charis Farm	17	X	1/2				
Cimarron Farm	130	X	1/2				

Table E-1. Continued

Classic Mile Training Complex	700	X	1	X	7/8		
Clearview Farm	44			X	7		
Clouston Training Center	71	X	5/8				
Corner’s Crossing	10	X	3/4				
Corner Stone Farm	21	X	5/8				
Covington Oaks Farm	62	X	3/4				
Coyote Crossing Farm	85	X	5/8				
Crown Center Farm	110	X	5/8				
Crupi’s New Castle Farm, Inc.	138	X	3/4				
Cupola Farm	120					X	5/8
D & B Farm	40	X	5/8				
D & G Thoroughbreds, Inc.	70	X	5/8				
D & J Buckley Farm	49	X	1/2				
Dare to Dream Farm, LLC	96	X	7/8				
Daybreak Farm	95	X	5/8				
Del Sol Farm	70	X	3/8				
Derby Daze Farm	80	X	1/2				
Dodson Farm	30	X	1/2				
Double Diamond Farm	420	X	5/8	X	5/8		
Eclipse Farm	385	X	3/4				
Eclipse Training Center, Inc.	240	X	3/4				
Emerald Pastures Farm	180	X	5/8				
Endeavor Bloodstock	23	X	5/8				
Fast Lane Farm	16	X	3/8				
First Turn Farm	10	X	1/4				
Flamingo Farm	75	X	1/2				
Fleet Crest Farm	60	X	5/8				
Flying Finish Farm	20	X	3/4				
Flying H Thoroughbreds, LLC	123	X	5/8				
Four Horsemen’s Ranch	170	X	1/2				
Four Roses Thoroughbreds	200	X	7/8	X	5/8		

Table E-1. Continued

Fox Brown Farm	60	X	1/2				
Fox Point Farm		X	5/8				
Get Away Farm	100	X	1/2				
Glen Hill Farm	400	X	5/8				
Glen Ridge Farm	115	X	1/2				
Gold Crest Farm	46	X	1/2				
Goldmark, LLC	2,500					X	3/4
Good Chance Farm	230	X	5/8				
GP Horses, Inc.	20	X	3/10				
Grand Oaks	10	X	5/8				
Gray Moss Farms	49	X	1/2				
Great Luck Farm	20	X	3/4				
Gulf Coast Farms, LLC	413	X	7/8				
Hampton House	120	X	1/2				
Haras Santa Maria de Araras, S.A.	190	X	1/2				
Harlequin Ranches	75	X	1/2				
Harris Training	80	X	5/8				
Hartley/de Renzo Thoroughbreds, LLC & Walmac South	105	X	5/8	X	3/4		
Herring Farms	371	X	5/8				
Hickory Meadow Farm	100	X	5/8				
Highland Tree Farm	40	X	1/2				
Horsin Around Farm		X	5/8				
Hyatt Farm	147	X	5/8				
Indian Prairie Ranch	197	X	1/2				
Iron Anvil Farm	16	X	1/2				
J. Toole's Thoroughbred Training Center	15	X	3/4				
JC Thoroughbreds	40	X	5/8				
J.K. Thoroughbred Farms, Inc.	66	X	1/2				
Nelson Jones Farms & Training Center, Inc.	734	X	1	X	7/8		
Journeyman Bloodstock Services, Inc.		X	3/4				
Kensington Farms, Inc.	50	X	5/8				

Table E-1. Continued

The Kindergarten	200	X	5/8		
Kings Equine Farm	65	X	3/4		
Kinsman Farm	750	X	3/4		
Kripple Kreek Farm	10	X	5/8		
Lake Magdalene Farm	192	X	5/8		
Lambholm South	1,800	X	1		
Live Oak Stud	4,500	X	3/4		
Lou-Roe Farm	111	X	5/8		
Lushland Farm	42	X	5/8		
Magic Equinox Racing Stables	85	X	3/8		
Magnolia Farm	50	X	5/8		
Manuden Farm	60	X	3/4		
Martin Stables South	385	X	5/8	X	1/2
Mayo West Farm	108	X	1/2		
McKathan Farms & Training Center	80	X	1/2		
McKibben Thoroughbred		X	5/8		
Meadow View Farm	40	X	1/2		
Menefee Training Center		X	1		
Millview Farm	10	X	3/8		
Moment of Glory Training Center	40	X	5/8		
Morton Meadows	65	X	5/8		
New England South	15	X	3/8		
New Episode Training Center, Inc.		X	5/8		
New Haven Farm	112	X	3/4		
Niall Brennan Training Stables	80	X	5/8		
Ocala Breeders' Sales					
Ocala Stud Farms	500	X	7/8		
Ocala Thoroughbred Farms, Inc.	105	X	1/2		
Ocala West Training Facility	65	X	5/8		
Olympic Hill Training Center	380	X	5/8		
Omega Farm	57	X	1		
One Pair Farm	100	X	5/8		

Table E-1. Continued

Oxford Farm South Inc.	110	X	7/8		
Paradise Park	80	X	5/8		
Parietta Farms	65	X	5/8		
Parrish Farms	50	X	3/4		
Partnership Farm	40	X	5/8		
Payson Park Thoroughbred Training Center, Inc.	750	X	1	X	1
Payton Training Center	100	X	5/8		
Pinecrest Stables, Inc.	429	X	5/8		
Plumley Farms	700+	X	5/8	X	5/8
The Pony Express	32	X	5/8		
Porter Racing Stable, LLC	150	X	1/2		
Prairie View Farm	15	X	1/4		
Prater Thoroughbreds, Inc.	60	X	1	X	7/8
Quarter Circle 4 Ranch	36	X	1/2		
The Racing Edge, Inc.	140	X	5/8		
Rancho del Castillo	10	X	1/2		
Rapid Run Farm	20	X	3/4		
Red Oak Farm	252	X	5/8		
Rising Hill Farm	400			X	5/8
Rockside Farm	30	X	5/8		
Rocky Valley Ranch & Training Center	77	X	5/8		
Rolling Meadows Farm	27	X	5/8		
Rosegrove Farm	100	X	1/2		
Rustling Oaks Farm	10	X	1/4		
Sab Training (Hawkinsridge Farm)		X	5/8	X	3/4
Sabine Stable	165	X	5/8		
Samerin Oaks	98	X	3/4		
Sam-Son Farm	160	X	1-1/8	X	1-1/2

Table E-1. Continued

The Sanctuary – Equine Sports Therapy & Rehabilitation Center	30	X	5/8		
Santana Farm	80	X	1/2		
Robert N. Scanlon Training Center	100	X	3/4		
Sea Fray Farm	15	X	3/4		
Second Start Farm	40			X	3/8
Serve N Notice Farm	8	X	1/2		
Shadybrook Farm, Inc. & Training Center (Oak Ridge)	50	X	5/8, 1	X	7/8
Shady Paddocks Farm	23	X	5/8		
Shanbally Acres	60	X	5/8		
Sky Ranch	150	X	1/2		
Solar Meadows	110	X	1/2		
Solera Farm	227	X	5/8		
Solitary Oak Farm	80	X	5/8		
Something Else Farm	30	X	1/2		
Sorrento Oaks Farm	90	X	1/2		
Southern Chase Farm, Inc.	430	X	1/2		
Southpaw Stables	17	X	3/8		
Stand Pretty Acres	20	X	1/2		
Starting Gate Training Center, Inc.	101	X	3/4		
M. J. Stavola Farms, Inc.	1,500	X	5/8		
Steadfast Farm	34	X	3/8		
Stephens Thoroughbreds	90	X	3/4		
Straightaway Farm	160	X	1		
Stutts Stable	12	X	1/2		
The Summit Farm	140	X	3/4	X	1
Sunnyside Polo Club & Training Center	160	X	3/4		
Sunrise Stable South Training Center	160	X	5/8		
Swan Hollow Farm	90			X	3/4
Sylvania South	90	X	3/4		

Table E-1. Continued

Tara Stables, Inc.	56	X	5/8				
Team Block Thoroughbred	75	X	5/8	X	7/8		
Thoroblood Ranch	40	X	3/4				
Thunderhoof Thoroughbreds	165	X	1/2				
Thunder Ranch Training Center	138	X	3/4				
Tiffany Farm	17	X	5/8				
Top Turf Farms, Inc.	160	X	5/8				
Town and Country Farms	1,100					X	1/2
Trackside Farm	140	X	5/8				
Tradewinds Farm	42	X	1/2				
Treasure Farm	16	X	3/4				
Triple M Farm	180	X	1/2				
Tuk-A-Wile Farm	10	X	3/8				
Twin Pines Farm	180	X	5/8				
Vale Stud Farm	10	X	5/8				
Vegso Racing Stable	130	X	5/8				
Verbarctic Farm	65	X	1/2				
Robert Vickers Training Center	10	X	5/8				
Viewpointe Farm	24	X	3/4				
Vinery Stud, Ltd	220	X	7/8	X	3/4		
Wavertree Stables, Inc.	90	X	1	X	7/8		
Weathervane Riding Centre	20	X	7/8				
Wesfield Farm	104	X	5/8				
Why Me Farm	30	X	1/2				
Wild Falcon Ranch	100	X	1/2				
Wildflower Farm	45	X	1/2				
Willow Creek Ranch	90	X	1/2				
Winding Oaks Farm	1,000	X	5/8, 1	X	7/8		
Wingate Farm and Training Center	40	X	5/8				
Winner’s Edge, Inc.	10	X	3/4				
Woodfield Farm	53	X	5/8				
Eddie Woods Stables	240	X	1	X	7/8		
Gayle Woods Training	20	X	1	X	7/8		
Woodside Ranch	270	X	5/8				

LIST OF REFERENCES

"2008 Farm Directory." Florida Thoroughbred Farm Managers, Inc. Florida Thoroughbred Farm Managers, Inc.. 6 Dec 2008 <http://www.flfarmmanagers.com/>.

"About The Jockey Club." The Jockey Club. 2009. The Jockey Club. 15 Mar 2009 <http://www.jockeyclub.com/about_tjc.asp>.

"About the Breeders' Cup World Championships." Breeders' Cup. Breeders' Cup. 22 Apr 2009 <http://www.breederscup.com/content.aspx?id=20252>.

"About TOBA." Thoroughbred Owners and Breeders Association. 2009. Thoroughbred Owners and Breeders Association. 15 Mar 2009 <http://www.toba.org/about/>.

Andersen, Steve. "Santa Anita chooses Cushion Track." ESPN.com 24 May 2007 3 Jan 2009 <http://sports.espn.go.com/sports/horse/news/story?id=2881679>.

Curran, Jr., Bob. "Welfare and Safety Summit On-Track Injury Statistics Revised." The Jockey Club. 10 Apr 2008. 16 Feb 2009 <http://www.jockeyclub.com/mediaCenter.asp?story=327>.

"Cushion Track." Equestrian Surfaces: Information Pack. 2007.

Duckworth, Amanda H. "Right Direction." The Blood-Horse 49 (2007): 6987-6988.

Elliston, Robert N. "Racing into the Synthetic Era: The Turfway Park Experience." The Jockey Club Annual Round Table Conference. 20 Aug 2006. The Jockey Club. 10 Dec 2008 <http://www.jockeyclub.com/roundtable_06.asp?section=9>.

Fleischhaker, Tamara. "The Horse Capital of the World." Ocala Marion County Chamber of Commerce. 15 Jan 2009. 15 Feb 2009 <http://www.ocalacc.com/ocala_florida/templates/tourism.aspx?articleid=18>.

"Graded Stakes." An Explanation of the American Graded Stakes Process. Owners and Breeders Association. 22 Apr 2009 <http://www.toba.org/graded-stakes/>.

Hammonds, Evan. "A Step Ahead." theHorse.com 16 Sep 2006 10 Dec 2008 <http://www.thehorse.com/ViewArticle.aspx?ID=7661>.

Haskin, Steve. "Tracking Trainers." The Blood-Horse 49 (2007): 6994-6996.

"Industry Programs." NTRA Annual Report of the Membership | 2007-2008. 2008: 14.

LaMarra, Tom, and Jack Shinar. "Work and Thought." The Blood-Horse 49 (2007): 7000-7002.

Liebman, Dan. "What's Going On Here." The Blood-Horse 49 (2007): 6973.

McFarland, Cynthia. "It's more than Dirt." Horse Capital Digest 2007 30 Dec 2008 <http://www.horsecapitaldigest.com/content.php?id=12&section=3>.

McFarland, Cynthia. "On the Mark." The Florida Horse Sep 2007 30 Dec 2008 <http://www.thefloridahorse.com/content.php?id=124&type=feature>.

"New Era of Racing at Golden Gate Fields Begins Wednesday as Horses Compete on Tapeta." Horse Race Insider 5 Nov 2007 2 Jan 2009 <http://www.horseraceinsider.com/blog.php/Press-Release/category/california-fairs/>.

Nicholson, Nick. "Racing into the Synthetic Era: Why Keeneland Turned to Polytrack." The Jockey Club Annual Round Table Conference. 20 Aug 2006. The Jockey Club. 10 Dec 2008 <http://www.jockeyclub.com/roundtable_06.asp?section=8>.

Norwood, Robyn. "New Track Might Put a Bounce in Their Steps." Los Angeles Times 14 Sep 2006 10 Dec 2008 <http://articles.latimes.com/2006/sep/14/sports/sp-horse14>.

Popham, Mark. "Battle-tested." The Blood-Horse 49 (2007): 7003-7004.

"Schedules." NTRA.U Quick Fact. National Thoroughbred Racing Association. 22 Apr 2009 <http://www.ntra.com/races_index.aspx?id=3#>.

Shapiro, Richard B., John C. Harris, John Andreini, and Jesse H. Choper. "Equine Postmortem Program." California Horse Racing Board Annual Report. (2008).

Shulman, Lenny. "On the Right Track?" The Blood-Horse 49 (2007): 6976-6982.

Stover, Susan M. "The Epidemiology of Thoroughbred Racehorse Injuries." Clinical Techniques in Equine Practice 2(2003): 312-322.

"Synthetic racetrack surfaces for horse racing." Wikipedia. 2008. 30 Dec 2008 <http://en.wikipedia.org/wiki/Synthetic_racetrack_surfaces_for_horse_racing#Pro-Ride>.

"The History of the Thoroughbred in America." Museum Exhibits. 2004. National Museum of Racing and Hall of Fame. 12 Mar 2009 <http://www.racingmuseum.org/exhibits/nmr-exhibits.asp?varPage=27>.

"The Thoroughbred." The Jockey Club. The Jockey Club. 13 Mar 2009 <http://www.jockeyclub.com/thoroughbredHistory.asp>.

BIOGRAPHICAL SKETCH

Harmony S. Blackwell earned her Master of Science in Building Construction degree from the M.E. Rinker, Sr. School of Building Construction at the University of Florida in Gainesville. While pursuing this degree, she concurrently earned her Master of Architecture degree with a concentration in Sustainable Architecture from the UF School of Architecture (SoA). During her time in professional school, Harmony worked as a graduate teaching assistant for the SoA, teaching architectural design studios and structures courses in addition to serving as a guest critic on undergraduate design reviews. Prior to graduate school, she interned for one year with Alfonso Architects in Tampa, Florida on a design-build project in collaboration with the Beck Group. This allowed her to gain experience from the schematic design phase through construction administration.

Before interning with Alfonso Architects, Harmony earned her Bachelor of Design in Architecture degree from the UF SoA. Throughout the duration of this degree, she interned every academic break with Gora McGahey Associates in Architecture located in Fort Myers, Florida. Her experience with this firm ranged from being a runner to producing construction documents and attending site meetings for various commercial projects.

Within the fields of architecture and building construction, Harmony's research interests include sustainable design and construction as it relates to equine facilities and the rural landscape. Beyond these areas, her interests include photography, specifically architectural, panoramic, human and animal portraiture, as well as equine training and competition.