Laser Grading Sports Fields

What is Laser Grading?

Grading is the process of leveling a land surface to a desired gradient by cutting, filling, and smoothing the soil. In the athletic field construction industry, laser grading establishes surface elevations through the process of moving soil within a given area using a grading mechanism equipped with an automated blade control system.

Proper laser grading accomplishes an elevation change from high point to low point and a smooth surface without significant high spots or dips that could impede surface water flow. A tractor tows a laser-guided box blade over the field, cutting high spots and filling depressions until the field exactly conforms to the desired slope tolerances. Laser grading does have some minute slope undulations from tractor tires and surface installation equipment. Although it is the best available grading system on the market, there are still some minor fluctuations of ¼ to 1 inch.

Grading sports fields is necessary to laterally shed surface water from the field and other critical areas while also leveling the field to its surroundings to provide smooth transitions from surface to surface (e.g. infield skin to grass). Athletic fields are designed to have minimal slope so slope does not impact play of the game or allow water to stand on the field. Often a ½% slope would be recommended for a skinned infield, and a 1-1.5% slope would be common for a natural grass field. Laser grading is highly recommended because it uses machine controlled components to establish tighter tolerances for slope or finish grade.

Laser Grading During Field Construction

Laser grading is recommended for all phases of construction from subgrade to gravel to root zone materials to create the ideal, uniform profile.

During field construction, rough grading will take place when the contractor cuts and fills to level the subgrade of the field and establishes the proper compaction level requested by the planning engineer. High areas may need to be excavated, low areas may need to be filled to establish an appropriate grade. Providing the proper subgrade will impact the overall performance of the field. As mentioned, the main goal is to design a field to have minimal slope so the slope does not affect the play of the game, but still moves surface water from the field effectively.

University of Missouri – Photo courtesy of Brad Fresenburg, Ph.D..

There are many general grading schemes that can be used during field construction, such as sloping a rectangular field from side to side, end to end, or corner to corner. Other schemes include a turtleback configuration or constructing a crown down center field so it slopes downward toward each sideline. Baseball or softball fields can be cone

shaped or feature a crown in a line from behind home plate through second base to the outfield, sloping down to the sidelines and through the outfield to the fence.

Once the subgrade is established, the drainage system is installed and each layer of project-specified root zone materials, followed by irrigation system installation. Finish grading is then completed to achieve a smooth, uniform playing surface. If the field is installed correctly, the grade should hold for many years if proper maintenance techniques are used.

University of Missouri – Photo Courtesy of Brad Fresenburg, Ph.D.

Laser Grading on Existing Fields

When working with existing fields, the current elevation of the field must first be determined. To do this, the laser transmitter is set up in a location within view of the area to be documented. Using a grade rod, an operator documents the relative elevation at any location within the proposed area. The grade rod is marked in feet and inches and is equipped with a laser receiver. The grade rod is positioned perfectly vertical in a location. The receiver is maneuvered up or down on the grade rod to intersect with the beam sent by the laser transmitter. The operator reads and records the corresponding measurement on the grade rod - the higher the corresponding measurement, the lower the actual elevation. By documenting the relative elevations over a grid work of locations, the operator can chart the surface contours or topography of an existing area. This gives the field manager a better understanding of how the field is sloped, how water moves, and how to develop an effective grading plan.

It is important to note that when documenting relative elevations, these elevation readings are only relative to the height or elevation of the laser transmitter at that time. This is also referred to as Height of Instrument (HOI). If the transmitter is repositioned, the operator will come up with different readings on the grade pole. To allow for this, a benchmark is established at the time the elevations are documented. A benchmark is a location within plane site of the transmitter that is a permanent elevation such as a concrete pad, footing, or possibly the base of a fencepost. By establishing a benchmark, the operator can reposition the transmitter on a day to day or even year to year basis as long as the elevation of the benchmark doesn't change. By documenting the new reading for the benchmark, the operator can translate the new readings to correlate with those documented in the past. The benchmark is used as the reference elevation when positioning the receiver on the mast above the laser grading equipment. First the laser transmitter is positioned, turned on and programmed to the desired slope. The cutting edge of the grading blade directly below the receiver is positioned on the benchmark elevation. The receiver is raised or lowered on the mast to intersect with the laser bean. The receiver will remain in this position as long as the transmitter is not repositioned. Whenever the laser transmitter is repositioned, the laser receiver must also be repositioned to correlate with the elevation of the new transmitter location. The same process is carried out to position the receiver correctly when a grade rod is used.

After determining relative elevation and where the water can drain the most efficiently, the slope can be determined. Measure the length of slope to determine slope %. For example, if there is 4 feet of fall over 200 linear feet, that is 2% of slope (4/200=0.02). Determine if there are any problems between the points such as a big mound of soil which is holding the water back from draining or a big dip that is holding water. This process identifies problems and helps determine how much to cut or fill. The automated laser guarantees the two points (from high to low) will have continual slope with no significant holes or high spots to get through. The lowest point should be the benchmark so there is positive drainage.

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Formula:

Change in elevation x distance x 100 = Percent slope

**Formula does not account for different units of measure*

Laser Grading Equipment

Laser grading uses a laser system to control various types of leveling blades attached to machinery – box blades, bulldozers, trenchers, and motorgraders. A laser transmitter mounted on a tripod emits a thin beam of light that rotates 360 degrees over an entire construction site. This creates a continuous 360-degree grade reference to guide the laser receiver attached to laser controlled machines. The laser receiver, mounted on a mast attached to the leveling blade, detects the laser transmitter's beam elevation and sends the information to an onboard computer. The computer sends signals to the hydraulic valve, which controls the lift cylinders of the blade. The valve raises or lowers the machine's cutting edge according to the signals to maintain the correct elevation.

Laser systems can be automatic or manual. A laser controlled system automatically controls the grading machine based on the signal received from a laser beam. A laser indicated system requires the operator to read the laser indicator and operate the machine manually. Automatic systems offer reliable and precise results and protect against the loss of accuracy that human error can produce.

Laser Grading a Baseball Field – Photo courtesy of Brad Fresenburg, Ph.D.

Laser Transmitters

Laser transmitters project a beam over a given distance that is picked up by the laser receiver. The area of the laser beam emitted from the transmitter is called a laser light plane. The plane is a 3-dimensional area with an X and Y axis and Z as the height of the laser light plane. There are 3 types of laser transmitters:

- Single plane laser - A single plane laser can slope the Y axis while the X axis always remains level. This creates a flat plane that can extend uphill, downhill, side-to-side, or both. An example would be to set the transit up directly above the apex of home plate and site down a foul line to the foul pole. This line would typically be considered the X axis and is the same elevation (or level) for the entire distance. If a certain slope is needed perpendicular to the foul line, such as toward the dugouts, adjust the Y axis to the percent slope desired. Since the laser beam travels 360 degrees in a complete circle, the proposed elevation at the front of the dugout can be marked as well as the elevation for the pitching area, as long as the same slope is desired in both directions. If a different degree of slope is desired, readjust the Y axis in either direction. The downhill side of the axis is negative (-)Y and the uphill side of the axis is positive (+)Y.
- Dual plane laser - On a dual plane laser, both the X and Y axis are adjustable. The laser projects a plane which can be rotated to create any desired 3-dimensional orientation. It can also be used to parcel a field into smaller sections, which works well when a rectangular field is crowned down the middle. Using the same example, a 1% slope (downhill) from home plate to first base means the X axis is set at -1%. A .75% slope (uphill) to the pitching area means the Y axis is set at +.75%.
- Cone laser - A cone laser creates a conical grade. The laser beam can be bent up or down with the transmitter always being positioned at the center of the cone. A conical grade is used when a baseball or softball infield is graded from a central location between the bases extending in all directions, typically creating a grading plan with all the bases at the same relative elevation. With many cone lasers, adjusting the X and Y axis can tilt the cone forward, backward, left or right. Cone

lasers cannot be used on fields that are sloped side to side without total reconstruction.

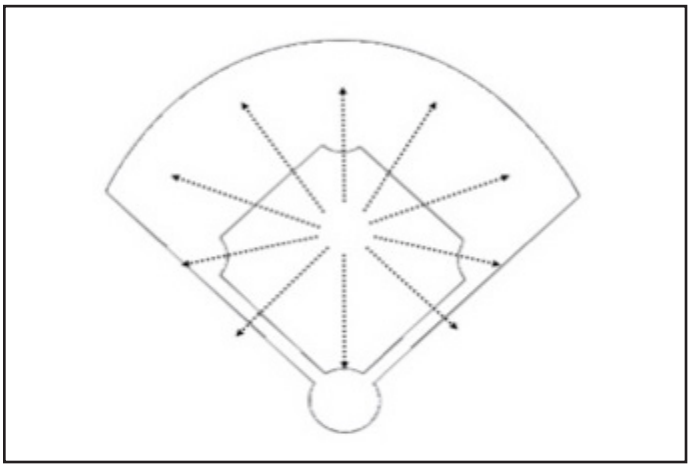

Figure 1: Infield graded with cone laser, showing equal slope in all directions - Graphic courtesy of HK Sports Fields

Regardless of the transmitter used, it is important to match the existing perimeter grades. It is at the operator's discretion how to set up the laser and how to tie into the existing elevations surrounding the field.

Laser Receivers

Laser receivers pick up the beam of light sent out by the laser transmitter. In the process of laser grading, the receiver is attached to a mast or pole that is mounted on the grading equipment. The receiver picks up the signal from the transmitter and sends the signal to a control box that simultaneously raises or lowers the grading blade to keep the cutting edge of the blade at a consistent elevation relative to the transmitter beam. Ultimately, the established grade will mirror the laser transmitter beam. There are two types of laser receivers:

- Single pole or single mast receivers - Single mast receivers are mounted in the middle of the cutting blade. The receiver receives the signal from the transmitter and controls the blade by either lifting or lowering the entire blade. This is a less expensive option.
- Dual pole or dual mast receiver - Two receivers are mounted on the cutting blade, one on each side. By controlling each end of the blade individually, a dual mast system can grade in any direction relative to the slope with equal efficiency and accuracy. This is a more expensive option.

Laser grading a football/soccer field – Photo courtesy of Brad Fresenburg, Ph.D.

Accuracy

Laser grading is generally more accurate than manual grading, but lasers do not guarantee accuracy. A laser system can provide grading that is accurate to within ¼ inch, and lasers can provide accuracy to within 1/8 inch. Most laser sources lose 1/8-inch accuracy per 100 feet of distance from the laser source. Therefore, if the source is placed on a side or end of a field, the far side or end cannot be graded as accurately. The laser source can be placed in the center of the field for improved accuracy, although this may prove to be problematic because it can get in the way of work. There are also laser sources available that lose only 8 arc seconds per 3,000 feet. With that degree of accuracy, the location of the source is not important for grading an athletic field.

Outsourcing Laser Grading Services

Laser grading project timelines will depend on the scope of work, field conditions and the type and quantities of material being leveled. Before beginning, the project should be fully defined regarding budget, project specifications, scope of work, timeline, material types and quantities, and topography/survey maps.

It is critical that the laser company be willing to consult onsite to establish the scope of work and material selection.

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Use a contractor that specializes in laser leveling to ensure the equipment and its operator are best suited to the project. Be sure the contractor is licensed and insured, familiar with materials, willing to coordinate delivery of materials with vendors in the area, and has sufficient experience in the business to provide referrals.

Laser Grading – Photo courtesy of Brad Fresenburg, Ph.D.

During the consultation, ask the contractor about the type of transmitter that will be used and the manufacturer's stated accuracy of the transmitter. Also find out how the contractor plans to use laser equipment to minimize loss of accuracy in the overall project. Specify a meaningful grade tolerance. Job specifications must give a noted deviation over a given distance. Laser grading contracts often specify tolerances such as "+/- ¼ inch deviation over 10 feet." Under those tolerances, a typical athletic field could be 4-6 inches off the intended plane. To prevent this problem, contracts should specify that the tolerance is "+/- ¼ inch deviation over the plane of the field" or "+/- ¼ inch deviation over 200 ft." This will ensure that no point across the full width and full length of the field will be more than ¼ inch above or below the specified plane. Modern equipment can grade to +/- 1/8 inch over the surface of an athletic field.

The bid document must have enforceable and measurable parameters so the contractor must perform to the bid document. Always check the contractor's performance for accuracy.

Conclusion

Properly graded fields begin at the design and construction phase. However, many sports turf managers must work with existing grades that were established during construction that took place long before they took over a field. A properly graded field will provide a smoother playing surface, decreased standing water, increased playability, fewer rain delays, decreased potential for injuries, fewer bad ball bounces, and reduced holes or settling in heavy play areas. Laser grading helps field managers to optimize field conditions by maintaining an accurate slope.

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