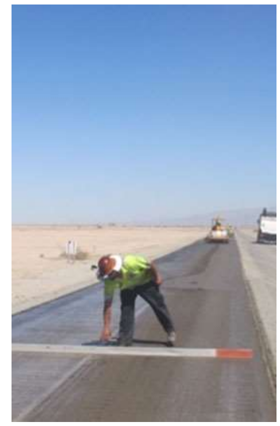
3D Milling for Smoothness

Responsible Renewal. Reliable Results.

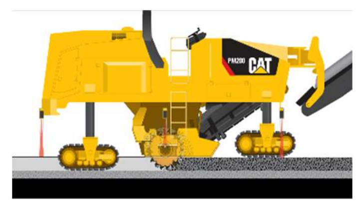
Introduction



Over the past few years, the use of 3D milling or "automated machine guidance" (AMG) in the rotomilling process has begun to take an ever-increasing foothold in the field of pavement rehabilitation. 3D milling utilizes data from a digital model of a pavement surface to automate grade control during the milling process. The result is a dramatic increase in accuracy of milling depth and an overall increase in roadway smoothness relative to traditional methods in which depth of cut is manually controlled by a milling operator or groundman.

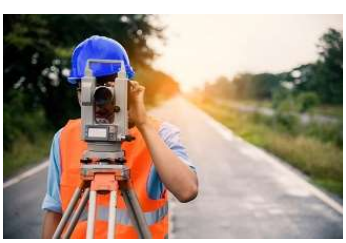
This paper will address the fundamentals of 3D milling including definitions and descriptions of the process, equipment utilized, benefits of 3D milling, and applications of 3D milling. Note that the concepts and technology discussed here may also be utilized in both asphalt and concrete paving operations, but this paper will strictly focus on incorporation of these technologies within the rotomilling process.

Basics

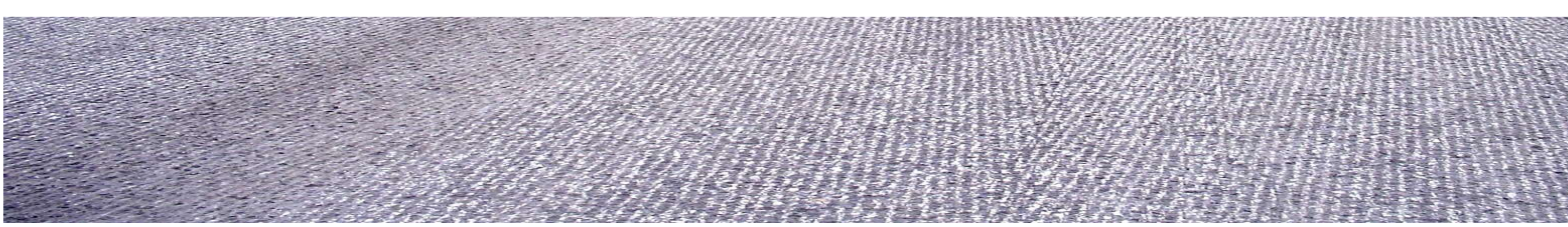


At a fundamental level, 3D milling may be simply defined as "a milling operation that utilizes a digital model and enhanced hardware to automate the machine's grade control." In a standard milling operation, grade is controlled manually by the machine operator or the groundman. This person must use the onboard grade control computer to key in a prescribed depth of cut. The 3D process eliminates this manual input and automatically controls depth of cut based on a digital model prepared prior to the milling operation.

3D milling may be utilized regardless of the type of milling drum the rotomill is equipped with, either standard milling drum, micro milling drum, etc. 3D milling only affects how the depth of cut is controlled and is independent of drum selection. While micro milling and 3D milling may be used in tandem, they are entirely independent concepts. Micro milling is a form of milling which utilizes additional teeth on the drum and leaves a finer milled pattern in the asphalt whereas 3D milling specifically refers to how the depth of the milling machine's cut is controlled.



The 3D process begins with a digital model, or "surface model." This model is created using an engineering software platform designed for creating these types of surface designs. Data may be collected from the roadway via traditional survey methods or via other methods such as truck mounted Light Detection and Ranging (LIDAR) systems. The latter method allows for collection of roadway data at highway speeds and provides millions of data points.



Once the roadway data is collected, the software user can create the desired surface model of the roadway. They can incorporate adjustments to existing cross-slope, longitudinal surface corrections, super elevation changes, etc. The resultant surface model is then uploaded to the milling machine's hardware. At this point, there are two primary methods of using that data in a 3D milling operation: "Absolute Elevation Systems" or "Relative Depth Systems."

Absolute Elevation 3D Systems

Absolute elevation systems utilize a fixed reference on the side of the roadway in the form of a total station. The total station must be set up and calibrated to a surveyed control point somewhere nearby. Once this calibration process is completed, the total station will then be at a precise known location in terms of latitude, longitude, and elevation. The total station then communicates with the milling machine (via a receiver affixed to the mill) and provides the mill with its own corresponding latitude, longitude, and elevation. Now that the mill knows its spatial positioning, it can reference that position with the data in the digital model and cut to a depth that allows it to reach the elevation as prescribed in the model. The total station constantly communicates with the mill and provides continuous updates as to the mill's positioning and elevation. The mill will therefore constantly modify its cutting depth to achieve the elevation dictated by its location at any point in time.

As the mill travels down the roadway, or around a jobsite, it must maintain line of sight communication with the total station. Furthermore, the distance between the total station and the mill is limited to around 500 feet. Therefore, it is necessary to set up multiple total stations throughout the jobsite, so that the mill can maintain communication with at least one at all times. As the mill travels down the roadway, it can easily switch its communication stream from one total station to another.

Relative Depth 3D Systems

Relative depth 3D systems utilize a slightly different workflow. They utilize the same or similar digital model, but rather than relying on the total station, the mill uses a GPS system to determine its latitudinal and longitudinal coordinates. The mill is affixed with a GPS receiver and additionally communicates with a GPS base station setup nearby. The GPS base station's job is to "fine tune" the mill's GPS coordinates. Standard GPS signals do not provide the degree of spatial accuracy required to meet the design of the digital model. Therefore, the mill must rely on the base station to make slight modifications to its GPS coordinates in order to create extremely accurate positioning data. Note that the mill does not need to maintain line of site communication with the GPS base station. The two components merely need to maintain radio communication with one another. Once the mill has determined its precise location, it can then utilize the model to determine what depth to cut at that location. At this point, the mill must rely on the existing surface and traditional on-board grade control devices to reference its depth of cut.

Benefits of 3D Milling

Smoothness

When using a digital surface model coupled with AMG, the mill can cut with extreme accuracy. This allows for both large and small surface irregularities to be eliminated. The result is an extremely smooth roadway ready for the application of an overlay or surface treatment. The 3D model can also be utilized by the asphalt or concrete paving equipment further ensuring a finished product that precisely meets the smoothness and 3D design tolerances set up in the digital surface model.

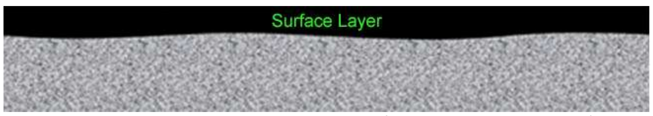
3D Milling for Smoothness

Grade Correction

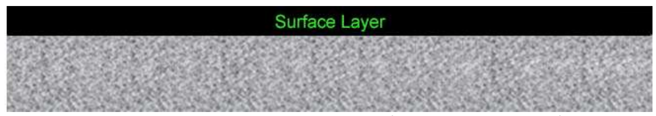
Oftentimes roadways, parking lots, etc. call for very specific and sometimes complicated grade corrections. Complications might include a roadway that requires cross slopes that must vary by location, a roadway that must transition in and out of super elevations, or a parking lot that needs precise grade adjustments to ensure proper drainage. 3D Milling allows for these corrections to be made automatically and eliminates error prone manual adjustments made by the operator or groundman.

Consistent Overlay Thickness

Historically, grade corrections and cross slope corrections have been made as part of the paving operation resulting in varying thickness of the final mat which may also require a leveling course to correct. Low spots or valleys are filled with extra material and high spots or peaks result in thinner than designed overlay thickness. 3D milling prior to these surface treatments allows for those variations to be eliminated beforehand. This allows the overlay to be placed with a consistent thickness throughout the entire project and eliminates the need to utilize a costly leveling course to achieve grade corrections.



Inconsistent Mat Thickness (without 3D milling)



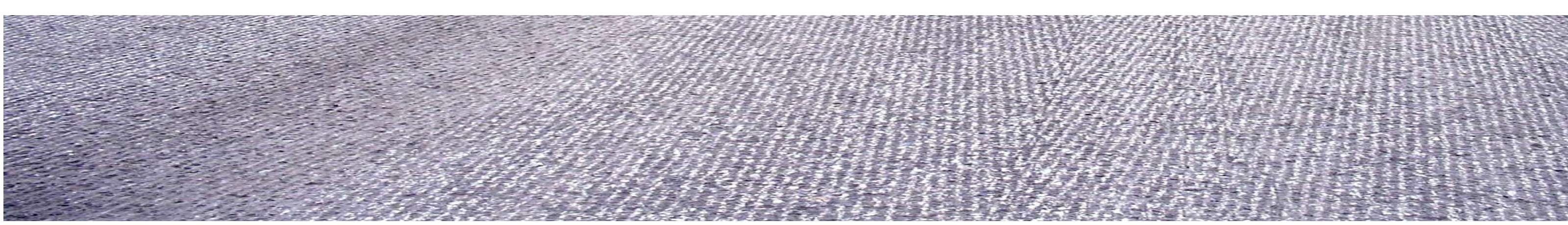
Consistent Mat Thickness (with 3D milling)

Density Uniformity

Density in HMA pavement is generally achieved by establishing a rolling pattern on a project and then following that pattern throughout the day. On jobs where HMA is placed at variable depths to correct ride or cross-slope, select areas can be over-rolled or under-rolled. This can create non-uniform density throughout the pavement. Due to the fact that milling in 3D minimizes variable pavement thickness, a more uniformly densified pavement and longer lasting overlay may be realized.

Yield Management

Since the model is created prior to construction, the contractor and agency know precisely how much material will be removed. Thus, forecasting the quantity of material to be removed, the number of haul trucks needed, and the quantity of material to be replaced becomes significantly easier and more accurate. Furthermore, because the subsequent overlay can be placed with a consistent thickness, discrepancies between planned and actual quantities are greatly reduced.



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Cloud data

Certain 3D milling systems have the capability of transmitting elevation data directly to the cloud in real time. As grade is checked behind the milling operation, the data can be viewed instantly by anyone with an internet connection. This allows for the owner of a roadway to view the elevations of the milled surface and compare them with the proposed surface model in real time, dramatically simplifying and expediting the inspection process.

Other Applications of 3D Milling

While the most common application of 3D milling is smoothness and grade correction prior to asphalt and concrete overlays, the advantages of milling in 3D can be extended to other applications as well.

Surface Preservation Treatments

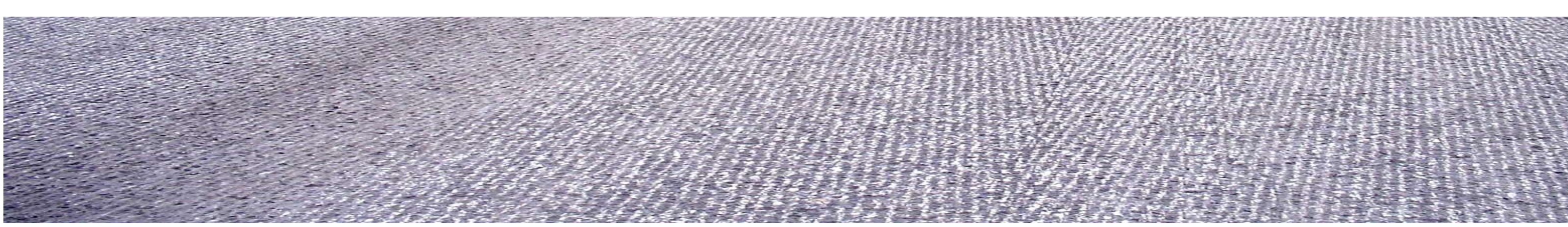
In the case of thin lift overlays or surface treatments such as chip seal, cape seal, micro surfacing, etc., grade or smoothness corrections are often difficult if not impossible due to the nature of the thin application. 3D milling coupled with micro milling can oftentimes be a remedy for this dilemma. The use of a micro milling drum in a rotomill creates a milled pattern with smaller ridges and valleys that are suitable for thin lift resurfacing applications. When employing micro milling and 3D milling in tandem, the mill may be utilized to correct grade issues while leaving a finer pattern on the milled surface.

Cold-in-Place Recycling

When Cold in Place Recycling (CIR) is utilized to rehabilitate a roadway, grade corrections are limited due to the fact that adjustments to the depth of CIR treatment can result in inconsistent mixtures of the recycled roadway. 3D milling can be utilized ahead of the recycling process to correct grades prior to the recycling process. Additionally, 3D milling in conjunction with micro milling may be utilized on the finished surface of a CIR treatment to make minor adjustments to the surface prior to the application of the surface course over the recycled base.

Full Depth Reclamation

Similar to CIR and surface treatments, micro milling and 3D milling may be used in tandem to make adjustments to the grade of a reclaimed surface prior to the application of a final surface treatment or overlay.



Conclusion

The benefits of 3D milling are extensive. Whenever grade corrections are required for rehabilitating an existing pavement surface, 3D milling should be considered as a primary means of accomplishing these goals. While the process requires some additional planning and coordination, the cost benefit of utilizing 3D milling for grade correction far outweighs traditional methods of using costly materials to make these corrections. Choosing 3D milling as the method for controlling grade ultimately provides a smoother longer lasting roadway for the agency and traveling public.