Bradley University

1501 W. Bradley Ave, Peoria, IL 61625

Safety Aspect of Asphalt Concrete Production and Construction

The Hazards and How to Handle Asphalt Concrete Production and Construction Equipment Properly According to the Occupational Safety and Health Administration (OSHA)

By Jaremy Hernandez

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Introduction

Asphalt concrete is a composite material that is commonly used to surface roads, parking lots, airports, as well as the core of embankment dams. For asphalt, there are two simple ingredients. The first ingredient is aggregate which is a combination of crushed stone, gravel, and sand. Alone, this first ingredient takes up about 95% of the hot mix asphalt pavement. The second ingredient is asphalt binder, and it takes up 5% of the hot mix asphalt pavement. Asphalt binder is a black/dark viscous material that holds the aggregates together. Asphalt is made up of polycyclic hydrocarbons which is a petroleum byproduct. Asphalt plants mix and heat the aggregates and the asphalt, then immediately loaded into trucks for delivery to the construction site, or it is kept in storage silos. [1]

Asphalt pavement construction is one of the most challenging professions in the construction industry for many reasons. On the plant and in the field, the workers are exposed to large equipment, complex machinery, and even the hot asphalt. Many safety hazards go with the equipment in the plant and on the site. It is essential to understand those hazards to prevent many accidents from occurring. The objective of the research is to explore the various safety hazards and OSHA (Occupational Safety and Health Administration) regulations on the activities in asphalt concrete producing equipment and pavement construction.

Background

Two approaches are followed to produce asphalt concrete, one is called batch mixing, and the other is drum mixing. There are few similarities and differences in between batch and drum mixing. There are a few steps for asphalt concrete production in batch mixing. First, the aggregate travels through the cold feed bins; there the initial proportioning of the aggregate takes place. The quantity of material leaving each bin is regulated either by the size of the gate opening, the speed of the belt, or a combination of both. The aggregate is then sent to a drier. While the aggregate is in the drier, the moisture is removed, and it is heated to provide the proper mixing temperature in the pugmill. The aggregate continues to the hot elevator by screens to the hot bins. The screens give the final separation of the aggregate. The various sizes of aggregate are released into the weight hopper one bin at a time. The aggregate is dropped into the pugmill for the asphalt to be mixed. Finally, the asphalt concrete is placed into a waiting truck, or it is moved to a storage silo. [2]

On the other hand, in the drum mixing procedure begins with feeding cold aggregates into the feed bins. Each bin has separate gates which can be adjusted to control the flow of the material. Below the bins, there is a conveyor belt that takes the aggregates to the scalping screen. During the screening process, there is a single deck vibrating screen that removes the oversized aggregates and prevents them from entering the drum. Charging conveyor plays a vital role in the asphalt plant process because it also does the weighing of the aggregates. The conveyor is equipped with a load cell that constantly weighs the aggregates and sends a signal to the control panel. The drying and mixing drum is responsible for 2 main operations: drying first and then mixing. The drum continually rotates, and during the rotation, the aggregated are moved from one end to the other end. The aggregates are treated with heat by the burner flame in order to reduce the moisture

content. The aggregates move away from the burner flame, and in the counterflow plant, the aggregates move towards the burner plant. At the other end of the drum, the heated aggregates are mixed with bitumen and minerals. Loadout conveyors collect the ready hot mix asphalt from below the drum and take it to the waiting truck or place it into the storage silo. [3]

The asphalt pavement construction process begins with the paver positioned correctly onto the road. The screed of the paver is lowered onto the block of the same depth of the loose asphalt mat that is going to be laid on the road. The screed is responsible for setting the depth of the asphalt mix. Then, the block can be removed, and paving can begin. Once the haul truck arrives at the job site, the paving instructor must check the asphalt mix and make sure it is in satisfactory condition. If there are any complications with the asphalt mix, it will be sent back to the batch plant to be reprocessed. When the first load of asphalt mix has been spread, the uniformity of the asphalt texture should be checked to avoid nonuniformity, segregation of material, and crown in the pavement. Once all is good, the last process of paving, compaction, can begin. The compaction process is highly influenced by major mix proportion; (1) asphalt content: aggregate size, shape texture, and distribution gradation; (2) filler content, and; (3) mix temperature. Appropriate rollers and rolling methods should be used by there proportions. There are other several roller combinations used for maximum results:

1. Steel-tired static and pneumatic-tired rollers,
2. Vibratory and steel-tired static rollers, or
3. Vibratory rollers used in vibrating and static modes.

These combinations are highly recommended by the Asphalt Institute. Rollers should be moved in a slow but uniform speed and be in good conditions to achieve the best results. If the rollers have any issues, it could result in poor compaction, and the pavement will not last very

long. A pattern that is economical and provides the maximum compaction result should be established according to the Asphalt Institute. [2]

Objectives

In the asphalt pavement processing plant, there are many equipment utilized to produce the asphalt. For this essay, the following pieces of equipment will be discussed: conveyors, burners, dryers and/or mixers, baghouses, primary dust collectors, dust and additive silos, and fans. The primary functions of each piece of equipment followed by the safety hazards that are associated with each piece and ending with OSHA's recommendations on how to handle each equipment without injury will also be discussed.

On the asphalt pavement construction site, there are many equipment utilized to complete the job. For this essay, the following pieces of equipment will be discussed: augers, stabilizers/reclaimers, milling machines, graders, sweepers, material transfer vehicles (MTVs), asphalt pavers, and compactors/rollers. The primary functions of each piece of equipment followed by the safety hazards that are associated with each piece and ending with OSHA's recommendations on how to safely handle each equipment to avoid injuries will also be discussed.

Safety Aspects Related to Asphalt Concrete Production Equipment

Conveyors

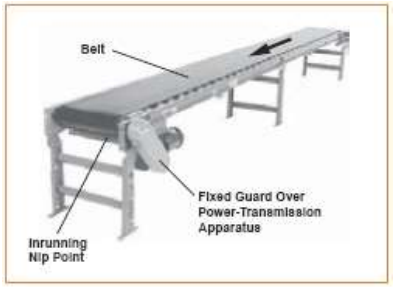

Figure 1

A conveyor system is a standard piece of mechanical handling equipment that moves materials from one location to another. Conveyors are especially useful in applications involving the transportation of heavy or bulky materials. The mechanical components include point of operation, power-transmission apparatuses, and other moving parts. The mechanical motions include rotation motion, reciprocating motion, transversion motion, cutting action, punching action, shearing action, bending action, and in-running nip points. [4]

Conveyors can lead to many injuries if they are not taken seriously. These hazardous activities could lead to worker amputation through machine set-up/threading/preparation, normal operation, clearing jams, machine adjustments, cleaning the machine, lubrication of the machine parts, and scheduled or unscheduled maintenance. According to OSHA, two basic methods are used to safeguard machines: guards and devices. Guards provide physical barriers that prevent access to danger areas. Devices function by interrupting the machine's operating cycle to prevent workers from reaching or entering the danger area while the machine is cycling. Both types of safeguards should be designed and installed to ensure worker protection. [5]

Burners

Figure 2

Burners remove the moisture content within the aggregate, and then the aggregate is heated to reach the needed temperatures. The safety hazards with burners are self-explanatory. Letting the burner go unattended can cause problems. A common mistake that has been discovered is that many people are trying to adjust air or fuel mixture by feel instead of the gas analyzing, or even not keeping track of the original settings of the burner can cause problems. [6]

A major priority with burners is to emphasize fire safety; it becomes everyone's job at a worksite. According to OSHA, to ensure safety in the workplace, employers should train workers

about fire hazards in the workplace and what to do in case of a fire emergency. OSHA also mentions how the fire plan should outline the assignments of key personnel in the event of a fire and provide an evacuation plan for the workers on site. For the construction industry, a fire plan must be set up before beginning any demolition job. [7]

Dryer and/or Mixer

Figure 3

The asphalt ingredients are continuously fed to the rotating drum that delivers a regular production of the hot mix. The hot mix elements are the aggregates, asphalt, and the mineral fillers. The aggregates are then transferred by the conveyor from the feeder bins to the rotary drum. The burner removes the moisture content from the aggregate, and then the aggregate is heated to attain the desired temperatures. The hot aggregate is mixed and coated with asphalt and the filler materials. The hot mix is then transferred from the drum to vehicles by the load conveyor. The feeder bins, pumping unit with asphalt tank, and the mineral filler unit are coordinated to maintain the proper proportion of the hot mix ingredients. The dust is accumulated by the dust collector, and moved through the pollution control unit before it escapes to the environment. [8]

The safety concerns with drum mix plants include the risks of burns from hot liquids, hot materials, and hot surfaces. There are also risks of fire from hot liquid ignition and falling from high places. OSHA mentions the importance of employees who are working in areas where hot work is being performed to be fully aware of the potential hazards mentioned earlier. Workers have ensured safety with employee orientation programs and periodic safety talks/bulletins used to provide them with the information. The use of personal protective equipment (PPE) is also required to ensure worker safety, and the workers should always make sure they are utilizing their equipment. [9]

Baghouses

Figure 4

A baghouse is an air pollution control device that removes particulates out of or gas released from commercial processes or combustion for electricity generation. Working near the baghouses can expose workers and others to cement dust from changing out filter bags or from performing inspections which can irritate the eyes, nose, throat, and the upper respiratory system. According to OSHA, the risks increase when handling and transporting materials that were removed from dust collection systems and while working near improperly maintained dust collection systems. That is why there must be specific procedures to be followed in order to diminish those safety hazards. [10, 11]

Using appropriate personal protection equipment can protect employees from potential exposure to lead dust. Ensuring that dust-control equipment is designed, operated, and maintained properly on a scheduled basis to prevent breakdown and release of lead to the ambient environment. When working on and when entering ventilation or dust-control equipment for maintenance or cleaning, implement proper permit-required confined space entry and energy-control procedures. [11]

Primary Dust Collectors

Figure 5

A dust collector is a system used to enhance the quality of air released from industrial and commercial processes by collecting dust and other impurities from air or gas. Designed to handle high-volume dust loads, a dust collector system consists of a blower, dust filter, a filter-cleaning system, and a dust receptacle or dust removal system. There is a possibility of combustible dust which is a significant safety risk for the employees if the dust were to ignite. OSHA talks about combustible dust and how they are fine particles that present an explosion hazard when suspended in air under certain conditions. A dust explosion can cause catastrophic casualties and the destruction of buildings. [12]

OSHA manufacturers and importers of chemicals recognize the potential for dust explosions and to identify appropriate protective measures. The evaluation helps ensure everyone has been provided with complete and accurate information regarding dust explosion hazards, the information on the labels, and making sure the workers are adequately trained in workplace combustible dust hazards. They also mention how adequate communication of hazards information is essential to ensuring that both the employees and their employers are aware of dust-related hazards and measures that can be taken to prevent the dust explosions. [13]

Dust & Additive Silos

Dust or additive silo is a structure used for storing bulk materials. Workers must be cautious since they can fall from the silo's ladder or fall from the work platform. Along with that, fires can emerge, and for those working underneath the machine, it is suspended feet above them and weighs several tons. If the silo falls on the workers, it will likely kill them. OSHA recommends many safety precautions to prevent any injuries from occurring. Their focus is on preventing dust explosions and fires. One of the precautions is to develop and implement a housekeeping program with detailed instructions on how to reduce the amount of dust accumulation on ledges, floors, equipment, and other exposed surfaces. Maintain proper maintenance and have regularly scheduled inspections for mechanical and safety control equipment. Moreover, minimize ignition sources by controlling hot work to also prevent an explosion from occurring. [14, 15]

Fans

Figure 6

With fans, there can be contact with rotating blades. An operating fan poses a significant risk of injury by contact with the propeller and must be treated with care. Indirect contact can also occur with blowing dust/dirt which can be particularly hazardous to the eyes and the respiratory system. A finger caught between the sheave and the rotating belt could result in severe injury or digit loss. Fan failure on startup is generally a rare event, but sometimes it happens. They encounter vibration, bumps, and

weather. It is not uncommon to find loose components on the job site, so thorough inspection of each fan on arrival is essential. [16]

According to OSHA, one of their standards requires employers to protect employees from exposed fan blades. If working with or near equipment exposes an employee to a hazard, then guards must be provided. It also specifies when the periphery of the blades of a fan is less than 7 feet above the floor or working level; then the blades shall be guarded. Employees should be aware of their surroundings and make sure there aren't any fans with exposed blades and employers should emphasize where those fans are located and how to maintain safety if the employees are working near them. [17]

Safety Aspect Related to Asphalt Concrete Pavement Construction

Augers

Figure 7

Augers are drilling devices that have a rotating screw blade referred to as a *Flighting* that is used to drill out material. Powered augers are mostly utilized in agriculture, landscaping, construction, and utility industries. They are commonly used to drill holes for pilings, utility poles, light poles, and fence posts. Many hazards come with an auger, whether it be with direct contact or indirect contact with the auger. Soil collected by augers is used for laboratory testing to determine optimum moisture content (OMC) to compact the soil bed and prepare for pavement construction. According to OSHA, synthetic fabrics are used in outdoor areas for purposes such as weed control or erosion control. The synthetic fabrics can get caught in the auger's rotation, potentially pulling a person into the rotation if they are standing on the fabric. Often, these accidents happen very quickly that neither the operator or the one standing on the fabric has enough time to react. The person can be severely injured to the point of amputation, or death. [18]

According to OSHA's Integrated Management Information System (IMIS), at least 13 fatalities have occurred because of entanglement or the crushing hazards with augers since 1987. They also mentioned that a couple of incidents have also occurred due to contact with underground and overhead electrical equipment and utility lines. OSHA has made recommendations on how to safely operate the machinery. According to the website, the recommended safety measures like following instructions in the manufacturer's operating and preventative maintenance manual. [18]

Stabilizers/Reclaimers

Figure 8

A stabilizer/reclaimer is a vehicle with a dual purpose. These machines have a large rotor blade which may be used to cut and pulverize damaged or old pavement, but which also may be used to mix lime, fly ash, or cement into the subbase in order to stabilize poor soils. OSHA, of course, indicates how there should be safeguards for moving machine parts, like moving blades, to ensure workers do not get injured. Employers are

responsible for providing a safe and healthful workplace for their employees. That in mind, anyone who is responsible for the operation, servicing, and maintenance of machinery with moving parts should read OSHA's *Safeguarding Equipment and Protecting Employees from Amputations* publication. It mentions how employers and employees must first recognize the contributing factors of amputation hazards. Understanding the mechanical components of the machine, the hazardous mechanical motion that occurs at or near these components and specific employee activities performed in conjunction with machinery operation will help prevent employee injuries. [19, 20]

Milling Machines

Figure 9

A top layer is milled off the existing pavement to provide a relatively smooth surface on which to pave. Milling is also commonly used to remove a distressed surface layer from an existing pavement. Milling machines are the primary method for removing old hot mix asphalt pavement surface material before the overlay. They can be fitted with automatic grade control to restore both longitudinal and transverse grade and can remove most existing pavement distortions. Milling also produces a rough, grooved surface, which will increase the existing pavement's surface area when compared to an ungroomed surface. [21]

There are 2 main types of milling machines: large and small. When using the large or small milling machines on the asphalt pavement, it can produce respirable crystalline silica dust. If this were to be inhaled by the workers, it could irreversibly damage the lungs because of the tiny particles. According to OSHA's fact sheet, wet methods reduce the amount of silica dust that becomes airborne while utilizing the machines. Equipping the large drivable milling machines with water sprays, exhaust ventilation and surfactants helps with effectively controlling silica dust production. With the small drivable milling machines, workers must use spray systems to spray a mixture of water and surfactants to control the dust. Workers are also responsible for proper maintenance to mitigate the amount of dust that is being produced from the small milling machines. [22, 23]

Graders

Figure 10

Graders may be used in place of milling machines if the base course is dirt or gravel. They are vehicles with large blades that create a wide flat surface for asphalt to be placed on. With an enormous vehicle, like a grader, there is the issue of blind spots, especially when backing the vehicle up. OSHA mentions that blind spots are dangerous because workers on foot often perform tasks that are near the moving equipment and vehicles, or they walk by equipment while trying to get to another destination. If a worker is in the blind spot, the operator of the machine will not see them and possibly strike them with the vehicle resulting in injury or possibly death. [24, 25]

Sweepers

Figure 11

Sweepers clean the surface of the road after it has been milled or graded. This is necessary because excessive dust and debris on the ground can prevent proper bonding between the asphalt and the base course. Large pieces of debris can also cause non-uniform compaction of the asphalt. For sweepers, OSHA has not classified this type of equipment as a powered industrial truck and, therefore, does not need to meet any requirements. Although there are no requirements for sweepers to be certified as an entity, there may still be circumstances where the element of a sweeper may need certification by a Nationally Recognized Testing Laboratory (NRTL). [26, 27]

Material Transfer Vehicles (MTVs)

Figure 12

MTVs are used to assist the paver in accepting hot mix asphalt (HMA). Most pavers are equipped to receive HMA directly from end dump or live bottom trucks, however, in certain situations it can be necessary or advantageous to use an MTV. OSHA requires that employers "furnish to each of [its] employees' employment and a place of employment which are free from recognized hazards that are causing

or are likely to cause death or serious physical harm to [its] employees." There is the possibility of a rollover hazard when workers are operating the piece of equipment on unleveled surfaces. Workers can become injured from the moving mechanical parts, and there is also the possibility of being struck by the vehicle if it is backing up and a worker is not paying attention. The risks are reduced if the area being paved is leveled, there is a rollover protection structure, moving parts are protected by guarding and interlocks, and providing back-up alarms. [28, 29]

Asphalt Pavers

Figure 13

The asphalt paver is a self-propelled formless laydown machine with a floating screed. Hot mixed asphalt (HMA) is loaded in the front, carried to the rear by a set of flight feeders (conveyor belts), spread out by a set of augers, then leveled and compacted by a screed. The screeds maintain control of the amount of material ejected into the base course and then it flattens the asphalt on the ground. The paving machine also aids in creating a leveled surface for compaction despite the condition the base course may be in. However, of course, the base course needs to be properly leveled to prevent cracking in the future. OSHA did not specify safety requirements specifically for asphalt pavers, but the same ones can be applied from the material transfer vehicles because they are universal precautions. [30]

Compactors/Rollers

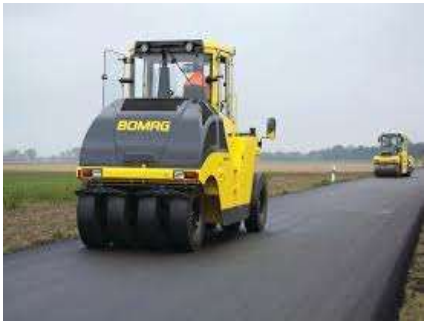

Figure 15

Figure 16

There are 3 basic pieces of equipment available for hot mix asphalt compaction: (1) the paver screed, (2) the steel wheeled roller and (3) the pneumatic tire roller. Each piece of equipment compacts the HMA by two principal means:

1. By applying its weight to the HMA surface and compressing the material underneath the ground contact area. Since this compression will be greater for longer periods of contact, lower equipment speeds will produce more compression. Higher equipment weight will also increase compression. 2. By creating shear stress between the compressed material underneath the ground contact area and the adjacent uncompressed material. When combined with equipment speed, this produces a shear rate. Lowering equipment speed can decrease the shear rate, which increases the shearing stress. Higher shearing stresses are more capable of rearranging aggregate into more dense configurations. [31]

OSHA provides a safety and health information bulletin for various reasons. They want to remind the employers and their employees of the rollover hazard when operating roller and compactor machines. They emphasize that rollover protection structure (ROPS) and seatbelts help reduce the risk of that occurring. OSHA wants to alert users and operators about operating on uneven surfaces and how operating on those uneven surfaces increases the likelihood of a rollover. Moreover, lastly, they want to encourage employers to carefully evaluate roadways and work surfaces where the rollers and compactors will be operated for hazardous inclines or declines. [32]

Summary

As mentioned, asphalt pavement construction is one of the most challenging professions in the construction industry. OSHA has created many guidelines when handling or being around the equipment to ensure worker safety and assurance. Many of those guidelines are updated with any emerging technology; however, not all guidelines have been updated. It is probable that some guidelines have not been updated since nothing has changed about specific equipment. It is important to update them when needed because equipment usage can change, and they need to continue to ensure their workers' safety.

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