# Best Practices for Level-Up Patching Operation

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16. Abstract

Level-up patching is a common corrective maintenance activity in Texas performed by most districts. It involves laying down a thin asphalt mix layer over an existing pavement in areas of sagging or rutting to improve the ride score and reduce pavement roughness. Level-up patching is used as a surface preparation step prior to another surface treatment operation or as a final exposed surface. This handbook describes in-detail the best practices of level-up patching, as established from a thorough literature review and information collected from various TxDOT districts through survey questionnaires and site visits. This handbook is intended for use by TxDOT field personnel as well as contractors that perform this work for TxDOT.

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# BEST PRACTICES FOR LEVEL-UP PATCHING OPERATION

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The United States Government and the State of Texas do not endorse products or manufacturers. Trade or manufacturers' names may appear herein solely because they are considered essential to the object of this report.

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# SECTION 1: INTRODUCTION

Level-up patching is a common corrective maintenance activity in Texas performed by most districts. It involves laying down a thin asphalt mix layer over an existing pavement in areas of sagging or rutting to improve the ride score and reduce pavement roughness. Level-up patching is a relatively, quick, straight forward, simple and inexpensive operation. TxDOT uses it extensively, expending roughly $100 million annually in level-up operations. Projects are primarily performed by in-house personnel, while a small percentage is performed by contractors. Three types of materials are used in these operations; hot mix hot-laid asphalt concrete, limestone rock asphalt (LRA) and special mixes such as 100% reclaimed asphalt pavement (RAP) blended with emulsions. This handbook describes in-detail the best practices of level-up patching as established from a thorough literature review and from information collected from various TxDOT districts through survey questionnaires and site visits. It is intended to provide guidelines to TxDOT office and field maintenance engineers, laboratory personnel, crew chiefs and foremen as well as contractors that perform this work for TxDOT.

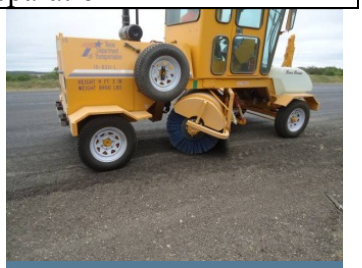
## SECTION 2: EQUIPMENT USED IN PATCHING PROCESS

Figure 1provides a pictorial catalog of the equipment and processes involved in the patching process.

Traffic Control

Surface preparation

1- Broom/sweeper



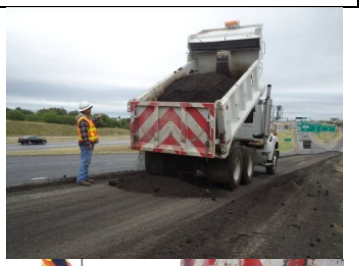
2- Roto-Mill machine: for full-lane milling

Tack coat application

Asphalt Distributor for tack coat application

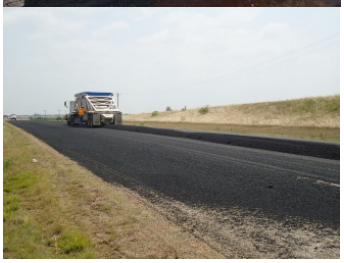
## Mix placement

1- Dump truck (end-dump)



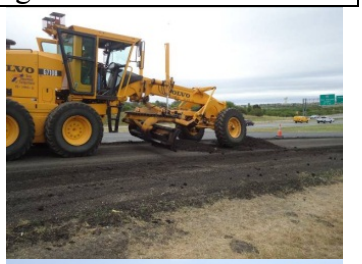
2- Dump truck/Drag box

3- Belly dump truck

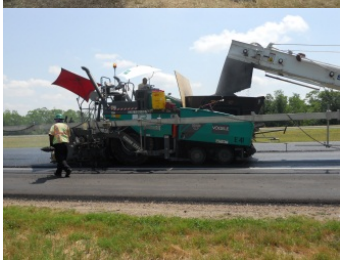


## Paving

1- Blade



2- Self-propelled paver / Lay-down machine



Layer compaction

1- Pneumatic wheel roller

2- Steel wheel roller (vibratory or static)

3- Water truck for filling water tanks in the steel roller

**Figure 1. Pictorial catalog of the equipment used in level-up patching**

## SECTION 3: LEVEL-UP PATCHING CONSTRUCTION: LAYDOWN, COMPACTION AND FINISHING

This section describes the recommended steps and best practices for field laydown, compaction and finishing the level-up patching process. The process involves ten steps:

Step 1: Setting the traffic control at both ends of the project site.
Step 2: Milling the upper ½ to 1 inch to remove the distressed material.
Step 3: Removing the vegetation along the shoulder and scraping markers by blading.
Step 4: Cleaning the pavement surface from debris and dirt using a broom machine.
Step 5: Distributing tack coat using Asphalt Distributor over the existing surface.
Step 6: Patching mix transport and placement.
Step 7: Mix paving.
Step 8: Roller compaction.
Step 9: Visual inspection and ride test.
Step 10: Set temproray asphalt markings and open for traffic.

A detailed description of each step is given in the following section.

Step 1: Setting the traffic control at both ends of the project site.

**Figure 2. Traffic control should be established prior to start of the operation**

Traffic control provides a safe working environment for the maintenance crew and safe travel lanes for vehicles. Traffic control operations should minimize the disturbance of the traffic flow as much as possible. All traffic control should comply with the Manual on Uniform Traffic Control Devices (MUTCD). Traffic control crews are responsible for providing a work area that is safe for both workers and drivers and for ensuring that all necessary steps are always taken to maintain safety. Cones should be used along the worked lane to isolate the crew and workers from traffic (Figure 2). Flaggers or a pilot truck can be used to control the through traffic, as the circumstance dictate.

For night operations, lighting is necessary to enhance safety at the job site. Although level-up patching is normally perforrmed during the day time, it is up to the district or area office to decide if night operation is needed. Urban sites with high volume traffic could be candidates for night operatiosn to reduce traffic disturbance.

Step 2: Milling the upper 1/2-1 inch to remove the distressed material

**Figure 3. Full-lane width milling to remove the deteriorated surface layer**

For better bonding and longer lasting patches, milling provides a stable base surface for the patching process. Milling can be perfomed over a full-lane width using full size self-propeled milling machines (see Figure 3) or over a partial-lane width (e.g., narrow strips along wheel path) using smaller size towable milling machines.

Milling is applicable where major distresses are confined to the upper surface of the pavement:

- High roughness in the pavement surface
- Low skid resistance
- Deteriorated pavement surface
- Deteriorated old patches

Milling is not applicable for treating:

- Low/medium rutting: except where the rutting in the wheel paths is associated with fatigue and block cracking propagating through the surface layer.
- Depressions, except where the pavement surface layer is deteriorated.

Step 3: Removing the vegetation along the shoulder and scraping markers by blading

**Figure 4. Vegetation, soil and marker removal along the side of the worked lane**

In preparation of level-up patching, vegetation (grass, bushes etc.) and soil covering the shoulder or being close to the worked lane should be removed (Figure 4) using a blade. In addition, raised pavement markers should be removed. Caution should be taken to avoid damage to the pavement surface. If marker removal caused any surface damage, it should be rectified according to Item 677 “Eliminating Existing Pavement Markings and Markers” of TxDOT’s Standard Specifications.

Step 4: Cleaning the pavement surface from debris and dirt using a broom machine. Cleaning should be done on both milled and unmilled surfaces.


**Figure 5. Surface dry cleaning prior to patching using a broom machine**

Cleaning the pavement surface from the dust, dirt or other debris is an essential step prior to tack coating. Paving on non-cleaned surfaces will reduce the bonding efficiency of the tack coat. A broom machine should be used to dry-clean the surface following the vegetation and marker removal described in step 3 (Figure 5). Two to three passes are normally sufficient to clean a 12-foot lane. Sweeping should be directed towards the edge of the pavement not towards the median for easier removal of the debris. Water should not be used with sweeping as it will affect negatively the function of the tack coat shot.

Sweeping should be completed on the entire job site before the tack coat application starts. Additional sweeping may be needed if dust or dirt is tracked onto the pavement from side roads or private access roads.

Step 5: Distributing tack coat using Asphalt Distributor over the existing surface

**Figure 6. Tack coating over full-lane width with regulated Asphalt Distributor**

The tack coat should meet the TxDOT specifications, including storing and applciation temperature, as described in Section 4. The recommended application rate is 0.04-0.10 gallons per square yard. The rule of thumb in tack coating is to ensure full coverage over the surface allowing for overlapping and without causing flowing off or dripping (Figure 6). After cleaning the surface (step 4), a tack coat is applied uniformly with the Asphalt Distributor vehicle driving at a uniform speed. The engineer or crew chief should use Tex-243F specification to verify that the tack coat has adequate adhesive properties.

The length of the tack coating area should exceed the proposed patching length by at least 10-15ft to provide sufficient transition for feathering the patching mix with the existing surface. The minimum width of coating should be the full-lane in order to:

- Fit the blade and lay-down equipment for spreading the level-up patching mix, and
- Restore the original crown slope of the pavement lane.

The asphalt distributor should be able to apply a uniform layer of tack coat over the patching area. Tack coat application rates heavier than required may lead to flushing of the asphalt in the wheel paths, while application rates lower than required may lead to de-bonding and delamination of the new patches. The engineer may allow the use of a computerized distributor system to verify application rates. These distributor computerized controls should be regulated to account for the speed of the sprayer, so a constant application rate can be maintained. One distributor is normally used in the patching operation. The spray nozzles angles and the bar height should be checked to maintain a uniform layer of binder with sufficient overlapping.

Tack coating should not proceed unless the following conditions can be maintained:

- Traffic control is in place,
- Sufficient haul trucks are on to the site with enough patching mix to cover the shot area,
- Haul trucks are in place behind the Asphalt Distributor vehicle,
- Air temperature is above 50°F and rising or it is below 60°F and falling,
- The emulsion provides adequate adhesion (according to Tex-243F),
- Uniform application and overlapping is achieved. Application should be stopped if the tack coating is non-uniform but exhibits streaking, ridging, paddling, or flowing.

Trouble shooting could rectify most of problems resulting in the non-uniform application of tack coats. This should include:

- Verifying equipment condition, operating procedures, application temperature, and material properties.
- Verifying nozzle bar injectors and bar height.
- Checking adhesive properties and viscosity. Emulsions that do not comply with specifications should be replaced.

## Step 6: Patching mix transport and placement

Mix transport involves equipment required to transfer the mix from the production plant to the paving site. Transport process includes truck loading, weighing, hauling to the site, dumping the mix on the roadway, into the paver or material transfer vehicle (MTV) hopper, and return to the production plant (Roberts et al., 1996). This process is applicable to all types of mixes, including patching mixes. The difference in transporting hot versus cold mixes is that the former require a thermal cover to maintain the temperature throughout the site transfer. Proper transportation plays a significant role in maintaining mix temperature and preventing segregation of the mix. Caution should be exercised when using with hot-mix hot-laid patching material to prevent cooling before it is laid and compacted.

Transport and placing equipment should be capable of adequately transporting the mix from a production plant to a paving site. However, certain truck types are best suited particular paving circumstances as the shown in Table 1.

**Table 1. Truck Type Situations (Roberts et al., 1996)**

| Situation | Possible Truck Type | Reason |
|---|---|---|
| Paving on congested city streets | Dump trucks (end-dump) | Better maneuverability because it has no trailer and is smaller than a bottom dump or live bottom truck |
| Paving on rural highways | Bottom dump | Usually has a larger capacity than end dump trucks (therefore fewer trucks are needed) but requires space and equipment for windrows. |
| Paving using a mix highly vulnerable to segregation | MTV | Live bottom trucks deliver the mix by conveyor, which minimizes segregation. |
| Must be accompanied with blade operation | Drag box | Helps to control the mix placement over localized strips |

Examples of transport equipment include:

**Figure 7. Placing the mix on the surface with belly dump and end-dump truck.**

1- Dump trucks (end-dump) and belly dump trucks (bottom dump) are best suited to both blade and laydown operation. Mixes should be placed over the surface or into the paving machine as seen in Figure 7.

**Figure 8. Drag box attached to the end-dump truck**

2- Drag box-equipped dump trucks are best suited for patching partial lane-widths or narrow strips (e.g., repairing rutting in the wheel path) as seen in Figure 8. They are mostly suitable to use with a blade patching operation. In such cases, it is not necessary to control the patching layer thickness, since it will be maintained by the blade and roller compactors.


**Figure 9. MTV used for hot mix patching operation**

3- Material transfer vehicles (MTVs) are used to maintain a constant flow of material from the haul trucks to the paver. MTVs lift the mix from their hopper, blended it and deliver it into the paver (Figure 9). MTVs allow the paver to operate continuously without stopping, hence minimizing aggregate segregation and temperature differentials.

## Step 7: Paving

Two types of paving operation are most commonly used in level-up patching, namely blade and laydown. These will be described next in detail.

**Blade operation**

After placing the mix with hauling trucks the mix should be uniformly distributed over the proposed patching area using the blade. This can be done in multiple back-and-forth passes. The speed of the blade should be controlled so that the mix is slowly spread across the lane. A blade speed of 10-20 mph is recommended. In each pass the blade fills incrementally the intended volume. The process continues until the mix completely fills the intended areas and the final surface is restored with the existing pavement cross slope (Figure 10).

Where the rut depth is 1 inch (the maximum allowed for level-up patching operation) the operation should be done in two stages (i.e., lifts) with ½" thick each. At the end of each lift a few passes of a pneumatic roller compactor is required for compaction. The second ½" lift should be placed and compacted in the same manner. Dividing the process in two stages allows better compaction and creates a stiffer and more stable mix with a smoother surface.

At the ends of a patching section, the blade operator should feather the mix to make it flush with the surrounding surface.


**Figure 10. Leveling up the mix with blade**

**Laydown machine operation**

Level-up patching with a laydown machine is similar to new pavement construction or overlay operations. The difference is that the laydown operation is performed in two lifts; a thin lift to fill

in the rut channels and restore the original surface cross-slope followed by a thicker lift of 1 ½", if needed.

The thin lift is done by placing the paver over the surface, maintaining the cross-slope, filling the patching mix in the rut channels and finishing with a pneumatic or steel roller compactor as shown in Figure 11. This patch can form the final pavement surface or simply the preparation for an overlay or other surface treatment. If an overlay job is planned, it should be placed immediately (i.e., in the same day) after the thin lift placement is completed. If a surface treatment is scheduled, it should be initiated 3 to 6 months following the first lift to ensure full curing of the level-up mix and tack coat.

**Figure 11. Thin lift level-up mix laid down to establish a base surface for the overlay mix**

Caution should be exercised under the following circumstances:

- If an overlay job is scheduled with the level-up patching, it is important not to combine the operation into a single lift. This will cause difficulty in compacting the thick mixes in the wheel path areas.
- If an overlay job is scheduled with the level-up patching, it is not cost effective to use a laydown LAR patch mix or a 100% RAP patch mix. The laydown patch mix properties must comply with the TxDOT specifications described in Section 4
- In blade operations, feathering at the end of the patch is extremely important. Humps at the patch approaches can result in mix delamination at the interface with the existing pavement due to resulting roughness-induced dynamic loads. This delamination can propagate throughout the patch (see Figure 12).

**Figure 12. Delamination between the patching mix and existing surface due to poor feathering**

Step 8: Roller compaction


**Figure 13. Pneumatic and steel wheel roller compactors used for compacting and smoothing the surface**

Two types of roller compactors shall be used, namely pneumatic wheel and steel wheel rollers. Their operation is described next.

The pneumatic rollers provide a more uniform degree of compaction, a denser surface that decreases permeability, increases density, and it is free of surface cracks caused by steel wheeled compactors (Brown, 1984). Pneumatic tire rollers are self-propelled compaction equipment that use pneumatic tires to compact the mix (Figure 13). At least one medium pneumatic-tire roller of a minimum 12-ton weight is required. Their compactive effort is controlled by varying the tire pressure, between 400 kPa (60 psi) and 800 kPa (120 psi) (TRB, 2000). Considering the thin layer of level-up patching mix, it is important to minimize the sticking of hot mix to the rubber tires. The roller should be run on the hot mat and let the tires heat up to near the mat temperature, prior to the start of the actual compaction. Also, the use of an approved release agent can minimize sticking. Asphalt release agents act as lubricating barriers between the tires of a pneumatic roller and the asphalt mat. This barrier inhibits sticking between the rubber tires and petroleum-based asphalt.

Steel wheel rollers are self-propelled compaction equipment that use steel drums to compact the mix. Tandem (two drums) rollers with a minimum of 12-tons weight each are required. The drums should work on two modes; static and vibratory (Figure 13). The drums should be equipped with a bar to spray water to prevent sticking with the mix. The vibratory mode should be used for the first four full passes followed by at least two full passes of static rolling. The vibration mode adds greater compactive effort than the static mode. Drum vibration facilitates the movement of the aggregates to allow them reaching an embedded position thus increasing aggregate interlock.

**Caution:**

- Typical compaction should start with 4 passes of a pneumatic roller followed by 4 passes of a vibratory steel wheel roller and finished with 2 passes of a static steel wheel roller.
- If only one roller compactor is available, increase its number of passes by 4 for compensation (e.g., 8 passes for a pneumatic roller, or 10 passes for steel wheel divided as 6 vibratory and 4 static passes)
- Pneumatic tire rollers should not be used as a finish rolling if excessive deformation occurs in the mat that are difficult or impossible to remove with further rolling
- Pneumatic tire rollers should not be used if excessive pickup of fines by roller tires occurs
- The vibration rate should be maintained at 3,000 vibrations/minute.
- Typically the speed of a roller should be maintained between 2.8 - 3.4 mph without stopping.

Step 9: Visual inspection and ride test

**Figure 14. A visual check with a rod or straight edge to check on the cross slope**

The engineer, maintenance section supervisor or the crew chief should perform visual inspection to evaluate the cross-slope and the longitudinal slope. A straight edge (Figure 14) and/or a test drive are acceptable means to evaluate the surface smoothness. The engineer, maintenance section or crew chief should decide if the work is accepted or if any further patching is needed before removing the traffic control and open the roadway to traffic.

Step 10: Set temproray asphalt marking and open for traffic

**Figure 15. Temporary marking placed at the road centerline**

Temporary reflectors should be placed at the center of the road as shown in Figure 15, until permanent lane markers are installed. The broom machine should be used to remove any debris or excess materials after the operation. Finally, the construction equipment and traffic control should be removed and traffic should be allowed on the roadway.

## SECTION 4: CREW CHIEF RESPONSIBILITIES

The crew chief usually sets the quality standards for the project. He/she must be familiar with the level-up patching process and know what to look for to achieve quality results. The key to a successful patching project is to have a knowledgeable chief who can perform the following duties:

Before the day of operation:

- Inspect the job site for any hindrances or obstacles that need prior arrangements,
- Review the job plans and estimate the amount of materials required,
- Estimate the time required to complete the job and the maximum length, (footage/mileage) of patching per day,
- Arrange for the proper equipment needed for the job,
- Ensure that the equipment is calibrated, and
- Arrange for the required staff.

During the operation:

- Check if the weather is permitting the initiation of the project operation. Make a decision to hold the operation if weather change during the operation may affect the quality of the project,
- Ensure that the traffic control arrangements are made,
- Manage the time to ensure that the job can be completed in the same day,
- Ensure that the asphalt is sufficient in the distributor truck and that it is heated to the correct temperature,
- Determine if enough material is being applied to the roadway,
- Monitor the operation to check the quality, and
- Recognize and correct any problems that arise.

After the operation:

- Evaluate the quality of the work and smoothness of the road,
- Order his/her crew for further work (e.g., re-patching, compacting) if quality is not achieved,
- Remove and clean the site of any debris or obstacles, and
- Ensure the safety of workers and drivers as they leave the site.

## SECTION 5: SPECIFICATION AND SAFETY REGULATIONS

### Specifications documents

All aspects of the level-up patching project must comply with the following specification documents:

- TxDOT's Standard Specifications for Construction and Maintenance of Highways, Streets, and Bridges: ftp://ftp.dot.state.tx.us/pub/txdot-info/des/specs/specbook.pdf. These specifications address quality of the materials and equipment, work methods and constructions and methods of measurement and payment.

- Special Specifications: supplemental specifications applicable to the individual project, not covered by the Standard Specifications: (http://www.txdot.gov/apps/specs/toc.asp?year=3&type=SP&list=all)

- Special Provisions: revise or supplement to the Standard Specifications or Special Specifications (http://www.dot.state.tx.us/insdtdot/orgchart/cmd/cserve/chngmemo/chngmemo.htm)

### Safety

Engineers, maintenance section supervisors and crew chiefs should refer to the TxDOT's Occupational Safety Manual and follow all safety procedures applicable to the level-up patching operations.

## SECTION 6: EQUIPMENT INSPECTION AND CALIBRATIONS

The quality of the level-up patching depends largely on the capabilities and limitations of the equipment at hand. Equipment must be properly calibrated and well maintained to have a successful operation.

Calibration and/or inspection procedures should be performed by the contractor or crew chief on the following equipment:

- Rotary broom
- Asphalt Distributor
- Dump trucks
- Rollers
- Blade
- Laydown machine

Inspections should be performed to make sure that there is no equipment malfunction, specially those that may compromise the safety of workers at the site. The manufacturer's safety procedures for inspection and operation should be used for all equipment.

Calibration should be performed to ensure that the equipment functions as expected. The manufacturer's manual is the main source of information to perform trouble shooting and routine calibration for each piece of equipment. Calibration and inspection shall be performed at least one day prior to the operation schedule. Plenty of time should be allowed to carefully inspect the equipment. Work should not begin until all problems are resolved.

More details on the calibration and inspection of the above equipment can be found on chapter 7 of the Seal Coat and Surface Treatment Manual (latest edition) (www.*onlinemanuals.txdot.gov/txdotmanuals/scm/scm.pdf)*

## SECTION 7: QUALITY CONTROL

This section is applicable for level-up patching layer only if it is left as a final exposed surface. The quality control and long-term performance of the level-up patching can be performed as part of the annual Pavement Management Information System (PMIS) data collection. Visual inspection, roughness, surface profile and skid test are examples of quality control tests that can be performed on the patches. Using the PMIS data require that the patching section being longer than 1/2 mile. Therefore, patches shorter than 1/2 mile should only be evaluated based on visual inspection.

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