June 26 EDC 2-HFST Local and Tribal Exchange Chat pod summary

1. What types of aggregates are considered for HFST application? How was that determined? What is their availability?

- Aggregates used in an HFST, by definition, have a higher Polished Stone Value (PSV). This is a laboratory test that measures the friction value after wear from an abrasive wheel. This test is used to predict the friction serviceability after it is exposed to traffic. These values have been correlated with successful HFST performance in field installations. Depending on the version of the PSV test used (ASTM or AASHTO), this value may be different, and so the same version of the test must be used to compare aggregate selections. Although several aggregates have been evaluated, only Calcined Bauxite aggregate has met the threshold for performance necessary to be called an HFST. PSV is a value applicable to a particular aggregate, not the road surface. Aggregate that has a PSV value over 60 is regarded as a High Friction Aggregate. The higher the PSV figure, the greater the resistance the aggregate has to polishing and the greater the ability the aggregate has to retain its own natural very fine texture (roughness). Typical values for a high quality, durable aggregate such as Calcined Bauxite generally exceed 70.
- Other aggregates such as flint, basalt and granite have been evaluated but have not performed as well as Calcined Bauxite. The other aggregate can be placed in a similar manner and may perform adequately in a less demanding environment, but in critical locations they have not provided the duration of friction service to be classified as an HFST. Other aggregates are being evaluated for performance, but at this time only Calcined Bauxite is recommended to provide the expected safety performance and durability.
- Although bauxite is a natural resource mined in three states in the USA, most of the bauxite used for HFST originates in either China or India. Bauxite is abundant in many countries around the world, with Australia producing the most bauxite of any country. Four of the largest international mineral companies (or subsidiaries) in the world are wholesale bauxite distributors in the USA. They typically import in large quantities and stockpile for distribution. The product is also resold at regional businesses. These are generally not the local quarry that paving contractors typically deal with, but the professional HFST installers have contacts that can supply any project need. The U.S. Geological Survey report states that a world bauxite shortage is not foreseen for the next century. http://minerals.usgs.gov/minerals/
- An HFST Aggregate Durability Study will be published later this year (2014) in cooperation with FHWA and NCAT. The study summarizes the findings of durability testing at NCAT for several different types of aggregates install on the NCAT test track.

2. What is the safety effect of these surfaces for motorcycles and bicycles? Is HFST bicycle friendly?

- There are no negative safety effects for motorcycles and bicycles. HFST provides a smoother riding surface and improved friction. HFST has been used for treatment of miles of bike lanes in the USA, and it has been applied as a safety countermeasure to specifically address curves and intersections with motorcycle crashes in the United Kingdom. Braking and cornering on a

motorcycle demands more friction than passenger vehicles. The following link is about a colored version of specialized HFST using a different aggregate and while not as high performance as calcined Bauxite it was not necessary for a demarcation effort https://www.youtube.com/watch?v=MuSVkoVd3Jo&feature=email

3. Bike groups have expressed concerns about the abrasiveness of HFST. How is this being addressed across the country?

- To date there has not been any identified problems regarding bicycle use on HFST. This product has been used widely for many years in Europe and in many other countries that have large bicycle populations and this has not been an issue. In fact the HFST process is being used to install colored aggregate that serves as delineation. This product has been requested by bicycle groups for bike lane surfaces. The texture provides a superior smoothness and should help reduce the problem of tires sliding when wet that is common on some demarcation treatments.

4. What is the effect of snow plows on this pavement treatment?

- The HFST treatment consists of a thin overlay designed to be less than 1/4 - inch in thickness. As such, the effect from snow plows has been minimal, even where bare pavement policies are followed in locations such as Illinois, Vermont, and Michigan. They are resistant to common de-icing agents. The polymer binder is unaffected unless it is flooded with diesel fuel or solvents.
- The bauxite surface wears very well under heavy snow plowing. No deterioration from steel-tipped plows has been observed

5. What is the average unit cost for HFST?

- Installed costs vary widely, depending on the size of the project, the prevailing labor costs in the jurisdiction, and the various components of the projects such as traffic control, treatment of pavement markings, etc. Projects accordingly have ranged from $25/SY to $35/SY as of a couple years ago. However the per SY price has been steadily going down for larger projects and where small installations have been bundled. In addition, only including work pertinent to the HFST project, and therefore increasing the chance of contracting directly with an installer instead of general contractors (GC), can give a better price.
- In comparing installation costs, there are several factors to consider. For example, the Kentucky Transportation Cabinet (KYTC), which has the most HFST projects (well over 100), had a significant number of projects on two-lane roads. On two-lane roads they averaged 750 SY each with an average installation price between $14,000 and $16,000 per project.
- A recent project in another state with multiple locations that totaled about 77,000 SY cost about $19 per SY. Multiple projects in California and New York recently were priced about the same. All of these projects included the total project cost in the unit prices, which included mobilization, traffic control, striping, remedial crack sealing, and patching in some cases. Also, they exclusively used Calcined Bauxite as aggregate.

- Most of the aggregates generally used for HFST (flint, granite, bauxite) are fairly expensive ($350 - $500 per ton). However, the aggregate is not the largest part of the HFST cost. The binder and the installation is the larger cost.

6. What is the cost-benefit ratio for HFST?

- A recent before and after study from the South Carolina DOT for a series of curve installations indicates cost-benefit ratios of about 24 to 1. Kentucky placed HFST on 26 curves and to date has seen an average reduction from 6.2 to 1.9 crashes per year at those locations. Additionally, the National Cooperative Highway Research Program (NCHRP) Report 617 indicates a crash reduction of 20% for all intersection crashes.

7. There has been some discussion of placing HFST in a double layer. Why is this done?

- Double layers are most commonly applied to bridge decks. The common treatment is to apply a double layer of polymer/resin and aggregate for insurance against water penetration of the deck, and to provide added durability to the installation. This is common for bridge deck preservation after a bridge deck is sealed and the treatment is used to restore friction, so the aggregate friction is generally not as important as aggregate hardness, so the aggregates used may not all meet the PSV qualification for HFST, but the concept is the same. If this same bridge was in a curve and also identified to have a crash problem, the bridge deck could substitute Calcined Bauxite and accomplish both purposes. This has been done in many locations across the country.
- Double layers may also be used on roads where snow chains or studded tires are common or as a treatment for pavement with an existing open grade friction course.
- A double layer should not affect noise any more than a single layer, as the surface texture generally remains the same.

8. What pavement conditions caused failures that have been reported?

- In North Carolina and in Colorado, two different problems combined to cause the underlying asphalt pavement to be delaminated: poorly draining pavement that trapped water underneath the HFST and cracking of the underlying asphalt pavement that reflected through the HFST. However, the HFST remained intact on the asphalt material.
- It should be noted that other sites in Colorado where the same overlay material was applied have maintained their integrity, despite being installed at altitudes of over 8,000 feet and being subjected to repetitive snow plowing.

9. What is the life expectancy of HFST?

- Life expectancy will vary with type of roadway, geometry of roadway, volume of and mix of traffic types, and nature of traffic movements. Accordingly, it is difficult to generalize. International experience indicates at least 7-12 years of service can be expected with correctly

applied installations. Some USA data indicates a service life of over 15 years in bridge deck applications.

- Vendors have reported from 5-8 years for 15,000 vehicles per day, and up to 5 years with 50,000 vehicles per day.
- Just like pavement performance, HFST wear is dependent on many things such as initial construction quality, friction demand, and traffic volume as well as the severity of the climate and the weight and number of heavy truck axles.
- Michigan reports 12-15 years of durability for bridge deck sites, including interstate highways with 48,000-62,000 ADT.

10. How does microsurfacing compare to HFST?

- As a pavement preservation technique, microsurfacing is far superior to HFST, and can actually extend the life of a poor pavement. In contrast, HFST is not a pavement preservation technique and is not recommended for application on poor pavement.
- As a friction-providing technique, HFST is far superior to microsurfacing. HFST aggregate by definition begins with PSV that rate much higher than the aggregates used for microsurfacing. The installed HFST supplies friction numbers (skid-testing) over 70 and many times in the high 80s or low 90s, which is well above those found with microsurfacing. Calcined Bauxite in particular can be expected to maintain a very high friction reading for many years into the future. Microsurfacing, by contrast, generally produces good initial friction readings in the low 60s or high 50s but then deteriorates within two years to the high 40s or low 50s (Michigan data).

11. Are HFSTs proprietary? Are there any good examples of generic specification?

- Virtually all HFST products are non-proprietary. However a product similar to HFST is Cargill's SafeLane, and it is patented and proprietary. The binder materials such as epoxy materials/ blends are generally trade secrets of the manufacturer, and certain application machines are patented.
- Currently, numerous states such as Florida DOT, South Carolina DOT, Maryland DOT, California DOT, and Texas DOT have developed specifications or special provisions for high friction surfacing.
- FHWA participated, along with the ATSSA High Friction Council, in developing a guide specification for HFSTs. The document has recently been approved for inclusion in the AASHTO Guide Specifications.

12. What is the difference between this treatment and a typical chip seal?

- Chip seals are a pavement treatment that can have some safety benefits but generally it is placed in large quantities to extend the life of the pavement, while HFST is a safety treatment that happens to be a pavement application, and it is placed in relatively small spots that are critical for safety.

- HFST is made for locations with high friction demand (shear forces) such as severe curves and braking areas, while chip seals don't perform well in those locations.
- The primary difference is the types of materials used. The HFST "binder" material is a polymer-based material as opposed to emulsions used for chip seals.
- The aggregate in HFST is much smaller (1-3 mm nominal size) than typical chip seal aggregate, and is specifically a very polish- and abrasion-resistant material.
- In terms of service,
    - Chip seal is a 5-7 year pavement preservation technique that can actually extend the life of a poor pavement. In contrast, HFST is not recommended for application on poor pavement.
    - HFST is an 8-12 year friction enhancing technique that supplies friction numbers (skid-testing) beyond conventional aggregates. Bauxite in particular can be expected to maintain this high friction reading for many years after installation. Chip seal, by contrast, produces initial friction readings lower than HFST, and the less polish-resistant aggregate typically used in chip seals generally loses its friction properties much more quickly than bauxite.

13. Is it always worth the investment to use HFST compared to other friction treatments?

- The answer to this question likely depends on (1) the condition of the existing pavement since HFST only lasts as long as the pavement it is placed on and (2) the severity and type of crashes. If you have a deteriorating pavement with substandard friction characteristics and minimal pavement life, you may solve that problem with more conventional pavement treatments by just restoring standard friction characteristics, at least for a short term. However, HFST may still be a good idea if the location has severe geometric features and high speeds, since this tends to escalate pavement polishing, so the problem may return even if you placed new pavement.
- When examining the relationship between Superelevation and side friction, all these factors are part of an equation to examine friction demand. California has elected to install HFST to tackle a lack of superelevation and deficient geometric on a section of highway in 2013. So far, no additional crashes reported.
- It is understood that many pavement preservation treatments (microsurfacing, chip seal, etc.) can improve available friction, especially on a polished pavement, and we are currently working to establish and quantify the beneficial impacts of improved and enhanced friction as a result of the installation of selected pavement preservation treatments.
- It may not always be necessary to apply the treatment that provides the highest, most sustained friction at a particular site; that would depend on the nature and severity of existing traction problems, life expectancy desired for the installation, and the friction demand produced by the traffic at the location.

14. Can patches that de-bond be fixed?

- This is not extremely common. However if small localized sections of HFST de-bond from the pavement, it can easily be repaired by cutting back to a well-bonded area and using hand

application of polymer resin and stone to blend the patch in with the existing material. This can be caused by an isolated spot on the pavement that was not cleaned well, or maybe an undetected solvent on the pavement.

- This may not appear immediately, but it is possible that the binder does not adhere well initially and the resin cannot transfer the tensile load to the structural pavement as traffic loads are transferred from the material and the force is pulling the material lose, or this could appear as the weather changed and thermal stress caused a release due to a poor bond. This is usually due to poor preparation like dust on the pavement, undetected solvents, or, specifically in the case of concrete, a lack of shot blasting as part of the preparation.
- More common is a small section pops out but the HFST is perfectly attached to a fragment of pavement. If this is a limited occurrence, this is not catastrophic event. Generally this means the underlying pavement had a weak spot and lost its bond. Again, the pavement can be fixed and HFST reapplied. If asphalt is used to patch the pavement, HFST should not be placed for at least 30 days, and if concrete is used then any curing compound must be removed and the surface cleaned before applying the HFST, since curing compounds act as bond breakers.

15. Will the polymer have a reaction with magnesium on a bridge deck?

- The issue is possible reaction with magnesium phosphate based patching like Set 45, not with magnesium chloride deicer.

16. What surface preparations are required?

- Surface preparation is the key for all successful HFST installations. Best practice is a clean and dry surface with ambient temperature above 50 degrees F (and rising), preferably 60F - 95F. Temperatures outside this range may affect working time for installing the material and/or material curing time as well as strength of the final product. However, some manufacturers have developed polymer resin binders that perform well at lower temperatures. Other polymer binders are available that can be installed at lower temperatures per the manufacturers direction.
- It is generally not practical to remove small oil spots, but very large or heavily saturated oil spots may need to be removed by removing and replacing the surface layer.
- Pavement markings that are not covered or consist of material other than paint should be removed. The method should be grinding, water blasting or other treatments; the surface should then be dried and swept clean prior to the polymer binder application. Pavement marking lines should be considered clean when the pavement has exposed aggregate showing through the existing marking. HFST will not fully adhere to thermoplastic road markings.
- Pavement cracks greater than 1/4 inch in width and depth should be sealed 30 days prior to HFST installation if rubberized asphalt or similar products are used. Otherwise pre-treat joints and cracks with the mixed polymer resin. Once the epoxy in the pre-treated areas has gelled, the HFST binder and aggregate topping installation may proceed.
- Repair all pavement defects such as spalls, pot holes, raveling and rutting prior to placing an HFST. Contact the manufacturer’s Technical Service Department to review which materials will

permit proper adhesion of HFST system. Clean and fill all inadequately sealed joints, including shoulder areas. HFST may be applied over pavements exhibiting minor rutting or heaving; however, the product is not intended as a repair for these conditions and will not level pavements.

For Concrete Surface

- The polymer resin overlay should not be placed on Portland cement concrete that is less than 28 days in place. Patching and cleaning operations should be inspected and approved prior to placing each layer of the overlay. Any contamination of the deck or intermediate courses, after initial cleaning, should be removed. Both courses should be applied within 24 hours following the final cleaning and prior to opening the area to traffic.
- Concrete surface should be abrasively cleaned by shot blasting or other means to remove oils, dirt, rubber, curing compounds, paint carbonation, laitance, weak surface mortar and other potentially detrimental contaminants, which may interfere with the bonding or curing of the overlay.

For Asphalt Surface

- Before placement of HFS on an asphalt concrete deck surface the entire deck surface should be cleaned to remove oils, dirt, rubber, curing compounds, paint carbonation, laitance, and other potentially detrimental contaminants which may interfere with the bonding or curing of the overlay. Acceptable cleaning is recognized as a surface with no oil spots, dirt or debris and the beginning exposure of coarse aggregate particles in the asphalt concrete.
- Areas of asphalt larger than one inch in diameter, or smaller areas spaced less than six inches apart, should be removed. High pressure air or a vacuum should be used to remove all dust and other loose material. Brooms should not be used.
- For applications on new asphalt pavements, it is recommended to wait a minimum of 30 days after paving before placement of HFST. On open graded friction course asphalt surfaces, stone mastic asphalt or pavement that has been treated with prior surface treatments, contact the manufacturer's Technical Service department for guidance.

17. What is the difference between mechanical installation and hand installation and what are the advantages for one over the other?

- Placement of the polymer resin can be installed by machine at a similar rate to other paving surface treatments, or can also be applied by hand or by tools. The selection of different methodologies is dependent on size of the installation, site specific conditions like storage and ready access, and availability of acceptable detour route or traffic restriction.
- Manual installation can be good. There had been several very successful hand installations by experienced installers but it varies by the crew and the oversight. The specification needs to be much more specific because of the higher risk since human beings make mistakes particularly when tired. Machines don't get tired. Binder thickness can be maintained by the notched

squeegee in theory but the automated device measures it automatically. Automatic is not without risk but much less risk.

18. Was the pavement friction measured before and after HFST installation?

- Locations identified for HFST installation should have the pavement friction measured as part of the HFST location identification process. The "after" measurement should be performed at least 30 days after HFST is installed and there would be nothing wrong with 60 or even 90 days. This will help agency's monitoring of the installations for years to come and to assess its effectiveness and durability.

19. Is installation over an open graded pavement an issue?

- Many HFST applications have been successfully installed on OGFC. However OGFC are relatively thin and vary in strength based on the aggregate used and the condition of the pavement. This has led to a few problematic installations since it often difficult to detect existing pavement issues. Successful installations over OGFC have used a double layer treatment in order to seal the voids with the first layer and maintain the proper binder depth of the top course with the second layer which is necessary for the aggregate embedment of the HFST riding surface.
- If you are placing HFST over OGFC, it may require the shoulder on the high side of the superelevation to be sealed to keep water from running through the OGFC and under the HFST, which can cause failure. It may also be necessary to extend the HFST further when the curve is on a grade in order to seal the OGFC to prevent water from running down the grade and under the HFST as well. This adds to the quantity of HFST so be aware.

20. What surface preparation and installation conditions such as temperature are required?

- Surface preparation is the key for all successful HFST installations. Best practice is a clean and dry surface with ambient temperature above 50 degrees F (and rising), preferably 60F - 95F. Temperatures outside this range may affect working time for installing the material and/or material curing time as well as strength of the final product. However, some manufacturers have developed polymer resin binders that perform well at lower temperatures. Other polymer binders are available that can be installed at lower temperatures per the manufacturers direction.

21. Can local agencies' workforce be used to apply HFST when using federal safety grant funds?

- Local workforce can be used to apply HFST similar to the same type of arrangement under the HRRR program. Just be mindful that proper training will be needed since install HFST is different than install pavement overlay.

22. Is installing HFST on steep slope a problem?

- The polymer when first apply to the surface is fluid and will run somewhat and hence it could be an issue for severe slope conditions. The way to avoid this is to have a very quick application of

aggregates onto the epoxy to lock it in place. The use of mechanical installation can minimize this problem during installation by having the epoxy spray on the surface and the spreading of aggregates to follow in split seconds.

23. What are the inspection requirements?

- There are many elements the inspection staff will need to pay attention to such as surface preparation, ambient temperature, and exposed epoxy. FHWA is in the process of developing an inspection checklist for HFST.

24. Can HFST be used for macadam tennis courts and basketball courts?

- Due to its abrasive texture of the surface, HFST would not be suitable for recreational sport courts. In addition, the cost will likely be higher than traditional surface treatments.