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Please stand by. We are about to begin. Good Dan welcome to today's embedded data collector and AASHTO innovation initiative webinar. I would now like to attend the call to Silas Nicholas, please go ahead.

Thank you and hello everyone. My name is Silas Nicholas. I'm a technical engineer with the Highway administration office of infrastructure and I want to welcome you to this webinar on the embedded data collector. The EDC is recognized by the AASHTO innovations initiative, formerly the AASHTO technology implementation group as an innovation ready to be blue point for use by state transportation agencies. They have three state your to presentations detailing recent experience with the embedded data collector from Bridge foundation projects. For those new to the technology, the embedded data data collector as a standalone dynamic testing method to monitor concrete pylon installations. They disease system consists of wireless radio controller connected to a gauge cast into the top and bottom of a concrete pile. For more information on the EDC system, please visit the website shown on the screen, aii.transportation.org. Have a lot of information to presented it. I'm going to get out of the way am at the presenters take over. As we get through this thing, of your questions, we will take them at the end. Use the chat, -- use the chat box on the screen to get questions in and we will log those an answer at the end of the presentation. At the end of the final presentation, we will have the phones lined opened up to allow people last questions over the phone. Are presenters will be Rodrigo Herrera, assistant State geotechnical engineer with Florida DOT, once or, structure and bridge geotechnical program manager with the Virginia DOT and finally, Mohammed, assistant state technical engineer with the North Carolina DOT. I will turn that presentation over to Rodrigo.

Thank you and good afternoon everyone. Think for joining us today. Let me start off by giving you a brief introduction as to our typical practice here in Florida. The majority of our bridges are supported on deeper foundations with the most common type of deep foundation being precast prestressed concrete piles. As per standard specifications, we require all the piles to be dynamically load tested. In the midnight these, our practice in many projects, even today, current practice still calls for the contractor to submit a piling installation plan where they detail the driving system they propose for a particular project. That includes a pre-field wave equation analysis. Once we go to the field we go with the test program and have the pile drive analyzer conducted to the test piles and we can take all of that data back to the office and run signal matching software called CAPWAP do determine the damping factor and distribution of resistance so we can take those parameters into weight equations to develop are driving criteria for the project. The criteria is provided to the field inspector for installation of productions. The criteria addresses the minimum number of [Indiscernible] per foot for the bearing layer, as well as maximum allowable stroke height, minimum tip and refusal conditions and set check requirements for cases where we think we are going to run into either set up or freeze conditions or maybe some relaxation of pile capacity.

By 1996, central office as questions about how to possibly improve the dynamic testing p rocess. Questions such as, what if we could instrument the piles without having to climb the leads?

Without delaying construction operations? What if we could monitor all of the pile so we wouldn't have to issue driving criteria. What if we could make all of this a little more affordable?

With that in mind, we contacted the University of Florida in 1997 and by 2002 they had issued a final report with proposed theory and the first generation of hardware and software. To summarize that effort, UF proposed the use of two levels of instruments cast into the pile near the pile had and tip. The used wireless transmission to a receiver in the field. US research and the UF method of analysis can be broken down into three steps, the first step is obtaining the ratio of the dynamic tip to skin forces. That's true the equation shown on the screen. That ratio is been dropped to that correlation, that provides the case damping factor and that can be computed for every single blow count or hammer strike on the pile. That case damping factor is used in case equation to estimate the total site capacity of the pile. Step number two is to calculate the static and bearing or tip resistance to the pile through loading point method and similar manner as we would analyze data from a static test. Step number three is obtaining the skin friction, the embedded data collector system subtracts the bearing calculated study from the total capacity. By 2003, smart structures Incorporated acquired a license to the patent tip technology and since then they've made advancements to the software, hardware and signal transmission aspects of the system. Around the same time, we issued a design standard index 20602. What I have on the screen is actually our most current standard. You can see that we have the details for the installation of the instrumentation in the pile and on this and some of the details of the installation of instrumentation depending on the number of strands of the pile and over here are some of the detail for the antenna. Taking a closer look at the pile itself, we can see that we have two levels of instruments here. As you can see, this is the pile had. You can imagine the hammer striking the pile had. We would have a stress wave that goes down and up the pile and all the data collected from the bottom level level of instrument is then transmitted to a cable to the top and data from both levels are transmitted from the antenna in a wireless manner to our receiver in the field. The picture on the left side of the screen shows you the instrumentation that would be placed near the tip of the pile. Connector cable and the instrumentation that would go near the top of the pile. But, again, has a connector cable to the antenna it will be flush with the face of the pile. At the center of your screen you can see the instrumentation. The loop once it's placed within the reinforcement of the precast, prestressed pile. This is showing as instruments obviously to concrete on the pile form.

Each level of instrument consists of a strain transducer, and accelerometer and the c ondition, that includes a temperature sensor. By the way, there is a temperature sensor embedded in the antenna box. Here, we can see the top photograph that shows essentially how to handle the antenna doing -- during concrete of the pile or casting of the pile form and finally, how an antenna would look with the pile phase when the concrete has cured. The center of the screen shows details regarding the antenna box, in terms of dimensions and general geometry. Couple of important features that the system allows us to do, even while the pile is in the casting chart include the measurements of strain within the core of the pile prior to and after cutting of the strands. That's typical practice. If the client so wishes to do, they can be taken continuously as in this case. Some discrepancies between these readings for this particular pile have top level of business installed at twice the pile with from the head of the pile and the bottom level at one from the pile tip. The second important aspect, the measurement of temperature, were be can get temperatures within the core of the pile and also at the level of the antenna and that gives a general feel for the curing process while the pile is still in the casting yard.

Taking a closer look at the antenna box, you can see that the corrosion protected battery used well the pilot is doing the casting yard, when the pile is delivered to the jobsite, the field inspector will explains -- exchange the battery for the battery pack used during pile driving. It's important to note that step is done while the pile is still laying on the ground. That eliminates the need for climbing up the leads, which is very important aspect of the s ystem.

In terms of software interface, there are many alternatives. This screen is a display of the raw data showing the raw measurements of strain and acceleration. It allows us to do a qualitative assessment of the data to check and see that the instruments are working properly. On this display, we have a more familiar screen when the top have would show us the forest velocity traces as recorded by the pump level of instrument and the associated wave down and wave of computer traces from the top level of instrument where the right side of the screen would have the summary of pile study capacity and pressure and tension stress as well as estimates of pile integrity. The third alternative is what's going on near the pile tip. In this case, we get velocity as recorded by tape gages as well as a little bit more detailed analysis of the substrates as it reaches the pile tip. As I mentioned before, it's gone through loading point by taking into consideration damping and inertia forces and to calculate the study force. Also, a very important aspect of the system, because they have instruments near the pile tip, compressed stress is not measured at that location.

As far as output, EDC can provide output in table form and in this particular example, we see a summary for the user and the project information as well as any notes that the piledriving inspector may have taken erring piledriving. On this side, you have a summary of the pile characteristics. In the table, itself, you have some columns here. The first being the tip elevation of the pile as is driven in the ground followed by a cumulative number of blows. Followed by the number of blows for a particular interval. In this case, the number of blows per foot and the associated average stroke Ike and transfer energy to the pile. Next two columns are providing us with two separate estimates of pile capacity. The so-called US method of analysis which we looked at in previous slides, being that three-step process I described early on and we will talk about some of the differences between the US method and the fixed method of analysis in upcoming slides. That is followed by an absent -- an absence of ways speed and measure top and tip compression stresses followed by the calculated tension in the the pile. The last two columns give an estimate of pile integrity. MPI over the measured pile integrity parameter that the system provides is a function of the changes in strain as recorded from the top and tip level of instrument between blows.

In graphic form, we can see that the system also provides, in this case, the graph for the tip elevation versus pile capacity of systems. In this case, we see both the US and fixed methods trace very close to each other. The pie was driven in the ground and reached the bearing there. With the horizontal dotted line representing the minimum tip, which is used to account for lateral stability in concerns with the deep foundation and the vertical dotted line representing the required nominal bearing resistance. In this case case you can see this pile clearly meets both criteria.

In gaining graphical form, we have tip elevations versus stress where the red line shows the measured compressive stress near the top of the pile and the blue line is the measured compressed stress near the tip of the pile and the gray line is the associated tension stress. In terms of calculation methods, the fixed case method uses a constant damping factor for the entire drive and that damping factor has entered into the system by the operator. In that method, only the use of the top level of instruments, in other words, a very similar computing procedure and the piledriving analyzer uses it. When using the embedded data collector system, it's preferable to make use of the US method because that is the method we looked at before and computes stamping for every hammer blow by making use of the top and tape gages and that allows for separation of static and dynamic resistance in realtime without the need to perform signal match analysis.

Now that we know how the system works, let's see how it performs. In 2006, FDOT decided to go into a two-phase evaluation process of the system with days when being an in-house effort that focuses on comparing the EDC to estimates of capacity from PDA and CAPWAP as well as stress and pile integrity and Phase 2 being handled by the nervous city of Florida and that is an ongoing effort that focuses on comparing EDC estimate -- estimates to static load test results. During our Phase 1 effort, when the main challenges was to collect a large enough database of piles that were monitored simultaneously with EDC and PDA. Of course, we make sure that data was collected by different companies so we would end up with the class A comparison.

The general approach for that face of evaluation was to take every drive for every pile that we collected for the database and tried to get statistical parameters for the entire drive. In this case, we have total assistance from the axis versus low number and you can see here the green lines represent the US method of analysis from EDC and the light blue lines represent the fixed method of analysis from the agency system and the red line is our PDA. Finally, we have here the ratio of fixed method to PDA and US method to PDA and we try to get statistical parameters for every drive, every pile that we have in the database. The same procedure was done for stresses that transfer energy and pile integrity. In this slide, we have a summary of the comparison for total static resistance and you can see our database ended up having in the access of 213,000 blows for comparison collected from 139 piles, where we had a fixed method over PDA ratio of .89 in USA method of .991 the standard deviation of .15 endpoint 16, all of which suggests a relatively small viability between the two systems with EDC generally trending on the conservative side.

As far as stress energy and integrity, the ratio of EDC2 PDA for maximum compression stress came at .92. For compressive stress near the pile tip, .75 maximum tension of .89, transfer energy of .95 and estimate of pile integrity at .96, all with associated standard -- standard deviations. Finally, the last step in that phase of the the evaluation was a comparison against CAPWAP. For that database we had 78 blows analyzed from 78 different piles and we see the ratio of fixed method of analysis to CAPWAP came at .88. US method came out 2.86. Again, with relatively small standard deviations, similar results we got when comparing to PDA where we had relatively small variation with EDC generally trending on the conservative side. I did want to share this next few slides with you. Regarding the comparison to cap while. -- FMCSA three. The US method versus CAPWAP method with R squared of .89, which is doing very well.

Wednesday move to static skin friction estimates, we have EDC estimate versus CAPWAP and square volume drops to about .57. When we look at and bearing, that is about .78. That indicates in terms of total capacity, EDC seems to be doing very well when compared to CAPWAP. When it comes to resistant distribution, this seems to be a little bit more scattered in the data.

One last important factor that we came across when doing the phase when evaluation, was addressing pile integrity. In this graph, on the first white axis, PDA, or beta parameter versus blow number for a particular drive. Here, you can see the red line representing BT at 100% on the initial portion of the drive, meaning that we don't have any damage on the pile and that drops to about 85% and blow number approximately 800 maybe. 85% all the way to the drive when it drops about 30%, clearly indicating the pile has suffered major damage. On the second axis, we we have EDC predictions for the same pile, delta at the tip is telling us what's going on with the strain within the pile between blows. You can see that parameter drops below number about 500, it goes beyond minus 50 micro strains. Infect, it continues to drop down to about minus 120 micro strain all the way to the end of drive when the instruments essentially stop reporting any meaningful data and we had a broken pile. This was a trend that kept coming up whenever we found piles that had certain issues. EDC seems to be doing a very good job giving us an early warning and that would allow the field inspector to take some action and try to prevent pile damage. What we believe is happening in those cases, is that the pile tip reaches the bearing layer, or maybe some cracking developing along the pile that results in a certain loss of prestressed near the pile tip and the tip instrumentation is picking it up. The strain gage near the tip exit up and provides an early warning and helps us make determinations as to how to proceed from that point forward. That turned out to be a very good finding that came out of Phase 1.

Going to Phase 2, the comparison to static load test we currently have 18 results. Anyone listening in today, if you have any static load test on prestressed -- prestressed concrete piles, please contact us. We would be interested in breaking bringing strike structures -- Smart structures and to save we can get those in tested, a few more results for the database for this effort.

Those that attended similar webinars last year saw this graph where we had all the results of static load test collected up to that point. We have capacity going up to about 900 [Indiscernible]. This is the updated graph. On the Y axis we have estimates of static resistance through the US method and here, we have the measured static resistance from static load test in terms of Davis on capacity. Some of the results will not be used in the database. In this case, for example, we had a pile that underwent a subject 13 days before the static load test on the side that clearly had significant set up and that data point is not really valid for the comparison. We had other two that did not approach Davis on capacity at the University is still going through the data and going through the analysis to come up with a recommendation or a final recommendation for the resistance.

Or. In the interim, however, we went ahead and implemented the system. What we have in the guidelines, as he can see, we have assigned the same resistance factor report, EDC, as we have for PDA and CAPWAP. Up here, you can see we use 2754 resistance factor projects where we have 100% dynamic testing, instrumentation on all the piles. Void 65 per projects where we have

5% or more of piles in the project instrument. We have also issued bulletins in the past addressing the mandatory use of EDC and testing production piles in an attempt to collect enough data to finalize our Phase 1 evaluation. By 20 -- by 2011, ABC was introduced as a standalone system in her workbook. By now, it's considered an acceptable alternative for dynamic testing and and it's in our standard specifications. I will let you go through some of the language we have in the standard specs when you download the PDF from the website. As far as cost, EDC instrumentation is going for about $899 per pile, that's two levels of instruments. An additional $100 for i nstallation. The workstation itself is least or $995 a month and if you also want to have access to the software for your office use, that is also least at $89 a month or $969 a year. On top of that we need to monitor the pile installation and that varies from one state to another, one project to another. In general terms, we assume about $500 per pile assuming production rate of about two piles per day and we encourage you to contact structures to get additional details.

Possibilities for the future, they have developed a couple new methods to estimate tip and skin friction. This brings about a bit of a more growth form solution where we would be adding to come up with total capacity and that a limited the need for making use of either case equation around loading points. Hopefully, eventually, at some point in the data collector, they also have the production methods available. For the time being, we still go with the US method. In summary, EDC is technology that was developed initially through FDOT funded research through the University of Florida under the direction of Dr. Michael McVeigh and FDOT preceded with an evaluation and step implementation of the system between 2006 and 2011. In summary, the system provides tip instrumentation, eliminating the need for signal matching, eliminating the need for climbing the leaves unless there are issues for that data, which nowadays is very infrequent. It also has measure of prestressed is, and measured loss of stress was provides early warning of developing pile damage, allowing pile inspectors to take corrective action. If there are any questions, of course, please feel free to contact us. If you have any upcoming tests and even if you don't have static tests coming up, if your projects you are going to have a large enough number of test piles, 10, 20, 30 or test piles where you have your PDA connected to that, we strongly encourage you to also look into and betting EDC instrument station into those piles so you can do your own comparisons and come up with your own conclusions, or you can contact us anytime if you feel weekend be of assistance in that effort. That's all I have for you today. Thank you, Silas. Thank you all for attending and I will hand it over to the Virginia DOT.

Thank you, Rodrigo. I'm happy to to be here today to fill you in the little bit on Virginia's experience with EDC. First, let me tell you a little bit about Virginia Highway system. We are responsible for about 58,000 miles of roadway work we have about 21,000 ridges in our system and annual budget is a little over $4 billion. Here's a picture of Virginia. If you notice, right here -- that me get this arrow -- this interstate 95 going through Virginia -- it pretty much follows the geotechnical fall line and what we have is marine sediments east of 95. We go into Piedmont and then the western part of the state is Ridge in the Valley. East of 95, Bement -- the majority are deep foundations on prestressed concrete piles and also along 95 we have three large metropolitan a reas, Northern Virginia area, Richmond Petersburg area and Norfolk Virginia Beach area. So, we have a lot of projects in those areas and, therefore, we drive a lot of prestressed concrete piles. Virginia's first experience with dynamic testing, as we all know what, was in the summer of 1984. It was for this bridge, the [Indiscernible] Ridge over the River just south of Eastern Virginia. The instrumentation was a lot different than it is nowadays. Then, we we had an analyzer that collected the data with a separate recorder that recorded the data and the waves were looked at on the oscilloscope. Significant changes have been made in that hardware and software, but the field process is pretty much the same. The project is engineered and drilling to install the gauges. Here are the strain gauge and accelerometer and here's the engineer climbing up in the leads to install the strain gauge and accelerometer once the pile has been placed. About two years after that job, we had another very large job come up that was a crossing of Hampton Roads in the Newport News Suffolk area for interstate 664. This is about a 5-mile bridge tunnel combination and being a large bridge like that, we had significant piledriving program. We did two preconstruction pile load test programs, what in the water and one on the land. We had 16 construction load tests and 45 construction dynamic analysis test's. The cost of that testing was about $800,000, but we estimate that we saved over $12 million in construction costs due to increased power capacities and another $2 million because of dynamic analysis allowing us to evaluate and reduce pile lengths. Here's some of the driving on that project. Here's some of the results. The red lines we've added are the dynamic analysis results. At that time, we were doing a three day re-strike and you can see the three day re-strike only got about 67% of what the actual ending capacity of the pile was. A five day re-stack better addicts what the future, capacity would be. Of course, it would've been great if we could have done a test of 30 days out to get more what the real value of the pile would be. That would be unrealistic to ask the contractor to wait that long before he could order his piles. What followed for us was 25 years of productive and of piledriving using dynamic analysis and in 2005, we had first exposure to the embedded data collect there's on our would were Wilson bridge project. This is the is the Woodrow Wilson Bridge interstate 95 crossing the Potomac River. On the left is Alexandria Virginia. To the right is Maryland and a few miles north, up the Potomac River is Washington, DC. On this project, we took six, 24-inch prestressed concrete piles and cast EDC's in the top and at the tip. His piles were used as driving test piles. Here's 11 of the piles being driven. Here's the data collector that was used to collect the data from the sensors. These tests were only partly successful due to problems we had with losing some of the sensors, possibly because of the heat of hydration after the concrete had been placed. That problem has been corrected over the following years and the survivability is quite good now and we don't have to worry about that condition anymore. Virginia didn't do any more EDC projects, but we did follow the Florida research and when the Florida research was completed and the use of the EDC was allowed in the floor specification, or Genia follows suit. In December 2011, we organized a one-day new product information transfer workshop on EDC for our consultants and contractors. The first project that used the embedded data collector was the Dominion Boulevard project in Chesapeake Virginia that was advertised in 2012. This was a replacement project for nexus to draw bridge that cause considerable traffic delays, numerous times of day women had to be opened. It was about 53,000 linear feet of power on this project and the contractor was very proactive in that he actually did some testing on his own. The first two piles he drove, he both used the conventional pile dynamic and L is a in and the EDC. The evaluations of those results were satisfied tree and he chose to use the EDC for the rest of the project. Here's some of that piledriving work being done. Once again, there is the data collector. Here's the pile after being driven and there, you see the transmitter in the pile.

Here is the data collector again and I've run through some of the slides similar to what Florida had shown you. This is the activation and connection phase that you use to turn the data collector on. Here's the configuration page where you enter the data for the pile and the project. Here again is the force and velocity curve page. You notice the four curves. In the past, it was just two. We have for now because we have the instrumentation in both the top and the tip. Here's some information on just the tip. And, information on just the top of the pile. As you can see, the numerous greens that you look at to evaluate the driving, this is a screen that I think is quite convenient to look at while you drive the pile. In the upper left corner, you see the red values that are the capacity. In the right upper corner, the black line is the stroke of a hammer and the gold line is the energy in the pile. The bottom left is the blow count and the bottom right, the green is the tenth stress and the maximum tensile stress in the pile. The blue is the maximum top compressed Gen Ed -- compression and the black is the maximum tip compression. You notice the break in the piledriving. But at this point, what that was, you can see from the green line that the tensile stress kept going up. When we reached the maximum allowable point, the driving was stopped. The new cushion was put in and there, you can see the drop-off in the tensile stress and we were able to complete the driving. What ways does Virginia plan to use these embedded data collectors? The new special provision allows the contractor to choose either the EDC or the PDA. We may may also begin on certain jobs to require that the first driving test pile has a top and bottom sensor and that's because as Roderigo told you, having that bottom sensor gives you additional information to evaluate whether pile damages occurring. We've all wondered for years what the piles really look at, like in the ground. Do we have significant damage. In many cases, we probably do. I think having that tip sensor will allow us to predict that and eliminate this damage in the f uture. Another thing, now, remember my slide showing the dirty day r e-strike making a better prediction of what the actual capacity of the pile was? Well, the embedded sensor allows us to do that. Most of the driving test we do are actually done on a pile that will be incorporated into the structure. When the contractor re-mobilizes to begin production piledriving, he can reactivate the EDC and we can do a second re-strike giving us sole setups week after the initial drive. That will help us economize are driving operations much better in the future. Another way I can see this being used would be to predict what the negative skin friction on a pile is due to down drag. We could go back at different stages and get that information to see how the the pile those are changing. We are not limited to just sensors in the pile, we can put sensors anywhere in the bridge struck for that we want to. We've actually done that on that Woodrow Wilson project, again, where the Turner Fairbanks Highway research center was doing a study for lifecycle monitoring and cost. One of the. Hats -- we had embedded sensors installed. Here, you can see those sensors, the sensors coming out of the pile. They did not use the remote transmitter on this one. This one was set up so that you had to come back to the site and actually use the generator to reactivate the piles and take the readings in that manner. In the future, if it so desires, you can set up a remote monitoring system where the readings could be taken and sent back to be evaluated at your central office location. We've also done some installations of the sensors on a drill shaft for a project on the I-95 hot line in the northern Virginia area. Here are the steps that were used to install those. Here's the collector being installed on the rebar cage. Once it's installed, it's checked to make sure that it's operating properly and that will be done before the cage is picked up and after the cage is put into the whole. Then, after the drill shaft is c ast, the sensors will be connected to the data collector. The data collector will then be placed on the form works and all the wiring connected. The concrete is poured pretty much in a conventional manner with not concern for damage. This may be a good idea not to just dump it right on their, but it has defector shields and the concrete operating can pretty much be done as normal. Then, afterwards here's the data are collection equipment again. It's set up and there's the data port on the edge of the cap. The information can then be connected via the wireless. Now, why are we monitoring these drill shaft? Well, there's quite a bit that we can learn over a long period of time. We can get the static load measurements at various locations along the pile and the cap. We can get changes in strain during live load debt and service loads. Of course can get the temperature at various stages and we can get the load transfer along the shaft. I think this information in the future will be very useful for any state that wants to go back to revisit the load and resistance factors. And, recalibrate them for local conditions and practices. This concludes my section and I will turn it over to Mohammed in North Carolina.

Thank you, Ashton. Thanks to the audience. We appreciate all the participation in this webinar. I'm waiting for my slides to show.

There will be a slight delay for you, Mohammed's not, -- Mohammed, since you are overseas.

Okay. Are you seeing them, yet?

No. It's still going.

Can you go to the first slide?

Yes.

Okay. Here is my -- I will talk about the department and experience with dynamic testing. I will talk about familiarity and experience with the DC, then I will talk about future plans for the E DC. Then, I will talk about some of the benefits of using the EDC. Next.

And CDO Geos use dynamic testing since 1987. We purchased the first blue box you see that PDA and 1997 we purchased the portable PDA with the does PA care version. The blue box with advanced PDA with Windows version and US software. Back now, I've got it, Silas. I can go. The end of 1980s we stopped using drill shaft foundation for p ressing. To be able to check them to get to the shaft, conceptual purchased the device in 1992. In 1993 purchased TNO device which is [Indiscernible] testing and in 2007 we purchased [Indiscernible] for the non-foundation program.

Dynamic testing for us is design process we used program to study the pile. We assume Hammer size based on our experience and hammers with contractors. Specific hammer energy to drive [Indiscernible] and perception, we evaluate the specific camber -- hammer submitted by the contractor to provide [Indiscernible]. If commended, then CAPWAP is used to define the WEAP analysis and generate the newer routing table.

Are familiarity with EDC started from prior to DOT. We at FDOT have ongoing research of embedded gauges inside the piles during construction. In 2002, Florida completed research and [Indiscernible] system. In 2003, Smart structures got license agreement from University of Florida. In 2007, Florida DOT mandated that all of the test piles must have EDC2 collect enough data to conduct their own comparison between PDA and static load test. In 2010, they adapted the use of EDC in this space as alternative to the PDA. During that time, applied foundation testing two small sections and they have a presentation and came to the department and encouraged us to use it and see how it works. In 2007, we looked to the bridge, [Indiscernible] Sampson County and that bridge has small piles and concern about [Indiscernible] piles at that time time, wherewith they be able to install instrumentation of that size. As you see in the table, the length at almost 28 and 21 feet in length. We are prepared to use special provision and details as shown in the next slides.

I just highlighted this -- I'm sorry, my arrow is not working. See the highlight on your screen. Two different consultants run the dentist -- the test to get to different people doing the test.

[Indiscernible] this slide, this is the construction details for the instrumentation and this is already posted in the ABC worksite.

Here, you see the ABC on the wireless communication device and the PDA device. You see the blue cable going around and hooked to the pile.[Indiscernible] some technical issues with the ABC communication where the pile [Indiscernible] after we drove the pile a few feet into the ground. We have some problems because we didn't use enough depth at that time. What we decided to do, to dig a hole around the pile. Pile. Dig a hole around the pile to see that damage, that PDA gauge is to get [Indiscernible] during that time.

They have some difficulty with the ABC and during driving. After that, we got enough data to compare the PDA and ABC and you can see here from the server capacity, we are very, very close to each other. Like, smart search PDI.

As you can see here, that match between ABC drive and PDI forest drive. See the blue and yellow? This force of the ABC website.

As you see, experience with ABC, unfortunately we had experience through some reasons. At that time, they ABC post was three times around the CDS. We had no justified to use a. Also, was issue with [Indiscernible] justification. Was hard to use at that time and our confidence in this technology, we didn't have enough testing or experience with it. So, we tried to use some pilot practice to be able to use it.

This is our current and future plans. At FDOT we started from 2011 and try to allocate the big projects with the static load test. 2013, we are located all 3307, new bridge over gallants Channel in [Indiscernible] on to bet unfortunately, this project was delayed a few times. January2014, this project is in conception now and we have another project which is at 2633 double big dual bridge on US 17 over Cape fear River in New Brunswick and New Hanover counties. This project is under construction now.

This bridge has 57 [Indiscernible], 1000 pounds of very stressed concrete, the sizes range from 24 billion to [Indiscernible] and from 35 to 105 in length. The length of the piles of 78,000 feet. This, we decided to use five EDC test and one of those tests will be like a production test have PDA, static globe test and EDC test. EDC test will have PDA and four different [Indiscernible]. As is the from this bridge was -- across the swamp area. This is [Indiscernible] for investigation. You can see the creeks and wetland. Was really hard to access for investigation equipment. What we did, we hired the swamp bloggers. You've seen the show on TV. They cut trees and create access for the equipment. They were fast and efficient. They saved us time and money doing a great job. You see the [Indiscernible] part in the hard layer and use the the forwarded Paula -- footed pile all the way. You see the next slide it is the voided pile all the way to the top. I just want to add, instead of [Indiscernible] the pile, the contractor used five piles with welded angles and cross plates to mimic the square shape of the concrete pile to break the layer vibrating [Indiscernible] elevation a few feet above the elevation.

That worked very well with the system.

This is another detail for this pile, that EDC and [Indiscernible] and this is a review posted on the website. This is as you see, the basket to connect the PDA gauges and you see the newer, smaller antenna for the EDC system. Here, the PDA guide and selecting the [Indiscernible].

After the initial drive, the r e-strike the pile after four h ours, 24 hours and 72 hours. Wait until the contractor prepared the static load test frame. As you see, from the load values, the design load 1600 and 60 tips pile cracked that 1641 and that's capacity for this 4441 kips. As you see here. What's happened, we see some indication of damage in the pile during driving and this pot was kept almost 2.6 feet to fit the frame. So, we are still investigating why the product flag before reaching ultimate capacity.

The second project is [Indiscernible] channel and this has 28 -- 471 piles or [Indiscernible] and the test pile was 105 feet long. The total length of the pile is 46,000 feet. We decided to have four EDC tests on this project and one of them was static load test and PDA on EDC. The other were just PDA and EDC and three different reduction events.

I just want to show you now, this is another place of expanded bridge, this is the pile and has four data points and this gives us a static load test. This is [Indiscernible] for EDC.

You see here the product is placed on [Indiscernible] for driving. Before we do that, the PDI guy has to go climb the leaves to hook the gauges, even though the PDA is wireless, we still have to -- at the bottom before damage in the gauges.

As you see, that EDC is [Indiscernible] and used success with that. Will pursue this [Indiscernible] this project as learning from the spreads, we are going to see how we implement this system as alternate to the PDA and our turn to process. Also, by participating in this program, the AASHTO initiative, the program was a great experience for FDOT. For still helping review the data and providing all the information we need. I think every one of them [Indiscernible].

Here's some of the benefits I listed. [Indiscernible] 30% to 40% is reasonable to use it now. The minute over driving of the piles and detect pile to damage, efficient time, no need to [Indiscernible], improving safety. Reuse for for existing foundation or future testing. [Indiscernible] the future of testing, like the bridges or any roads or the piles. This is my presentation. Thank you very much.

Thank you, Mohammed. Okay. We've got a lot of questions and a lot of discussion in the chat room while we were talking there. But I'm going to do, Ricardo and Aneesh, between the two of you, there are 14 questions in there. Who try to get to as many of them over 25 minutes as we possibly can. I want to be able to get two callers to see if that questions on the line, also. I will answer a question from Bob Solomon purse -- first. Maria will make a file share pot available as we close out this webinar so you can download the state presentation. We will start with the first question. Roderigo, I will turn this one over to pick why is there no correlation of EDC and static load test instead of compares for PDA? That's a question from Ricardo.

Thank you, Silas. How are you doing Ricardo. I think if you go back in my presentation and you probably have the one I gave last year, and D r. McVeigh had presentation two weeks ago in Gainesville. I'm not sure you were able to attend that, either. If you look in the presentation we had today, you see that all of the static load test results we collected so far are in their and we have 18 results in there. I think Doctor McVay separated some of them into total capacity, bearing and side friction. We have decent numbers of static load test. Obviously, we would like to have have more and that's why I was asking the audience to contact us if there are planning on doing any, so we can get those piles instrument it. But, we do have a decent amount thus far and we are hoping to get some more.

Kyle, any questions queued up on the telephone?

If you have any questions on today's conference, these press star one on your telephone keypad. If you are on a speakerphone, please make sure the mute function is turned off to allow your signal to reach are are good. A voice prompt will indicate when your line is open. At that time, please state your name before posing your question. Once again, star one. First question.

This is Mark [Last name indiscernible] calling from Philadelphia, Pennsylvania. The question I have, this sounds like a really neat technology. When can we really use it commercially. It seems the cost is very high. Is this knowledge of the future and always will be, or will this come to fruition on a large scale? Thank you.

Rodrigo, Ashton, Mohammed, I will let you take this as you are the pilot space, here.

If I can turn it in very q uickly, Silas, I think that's a very good observation. Of you go to the slide where we detailed cost, it appears to carry a significant cost with that. However, you need to keep in mind that some of the major benefits the system provides are in time s avings. If you have a large enough project, where you are doing 100% dynamic testing, and you eliminate the need to climb out the leaves and illuminate the need to run signal matching software, in the end, you may end up saving money through time savings, not necessarily on a one-to-one comparison to PDA. The comparison has to be done done looking beyond that. This is not just a comparison to current dynamic load testing methods. It has to be, especially when we talk about cost, we have to move beyond that. I think EDC is particularly well suited for large projects where you want to make use of a higher resistance factor and have 100% dynamic instrumentation.

Muhamed or Ashton, anything to add?

I would like to add, also, that EDC is like the future technology. You can use the same sense is inside the pile for future loading. You can load the bridge and lead in the future, not just like you do in construction. As Ashton showed, you go to the set up after 30 days or so. You get some of this result and get the temperatures settling. There's a lot of information you get from this technology. If we use that, the more we use it, the more we learn about it and the more it opens the doors for other technologies to come. This is the first technology to come after the PDA. It's really promising and it's going to work for big projects. You can save a lot of money if you have to -- if you have big projects and to change the resistance factor of your design.

This is Ashton from Virginia. By not, we are letting the contractors make the decisions that they can use either one that we've -- that they want to. At this point, I get a lot of calls from -- especially on design build projects, is to asking me the technology, so I think some of that contractor -- they are considering it, but we have not seen a great influx of what we have, other than that first dominion Boulevard and some of this work that I mentioned in my presentation. We don't have any others at this time, but there probably are half a dozen out there that are in the design build PDA area. It is being looked into. As a new technology, maybe the -- the suppliers are maybe not set up yet to furnish the equipment as economically as it might be in the future. If a lot of use is taken up, like I said, we are letting the contractor choose, but for Virginia, in that area where we are getting these large setups, having that additional information and realtime information of what the tip capacities are as we drive the pile, plus possibly getting this additional information on longer-term setups, I could see that -- I don't want to say a significant reduction, because the significant reduction in pie links came from and we went to dynamic formulas to the PDA. So, the big savings has been made. But, I think there will be some savings that could add up significantly, as was mentioned on a large project. Those are my thoughts.

Okay. Great. Why do we go back to the track questions. Rodrigo, I will ask you. Based on your experience, how do you evaluate the EDC tip gauges of their malfunctioning or the pilots broken?

Sure. We look at a couple of ways. The system provides a display that shows you the actual readings you are getting from the instruments. Have actual readings of strain and acceleration before those are converted to velocity. You look at the acceleration readings on the screen. That's one way to check that your instrumentation is working p roperly. Everything else comes back to zero after you hit the poly on the stress goes to the instrumentation. Instruments are not doing doing that. Obviously, that may be an issue with the instrument. Another way to check it is to check the wave speed. If you look at variations in wave speed, from the top gauges, for velocity wave upgrades down, you do the estimate that way. You can see that there are changes in voice be combined with potential issues described by the tip gauges that would be confirmation there may be an issue with the pile and not necessarily with the gauges, themselves. There's a couple of different ways to try to estimate whether it is instrumentation giving a false reading or you actually run to an issue with the pile. Keep in mind that generally, piles don't break in one shot. It takes several blows to do that. When the data quality begins to decay, like we saw in the graph that we had up on the screen a while back, relatively slowly, it's usually a very good indication that we have issues with the pile, not necessarily the instrument. Those are two or three different ways of assessing whether you have instrument damage or pile damage.

Kyle, any questions on the p hone?

We will take the next questions from the phone.

This is [Indiscernible] from Florida. I have a question to all the speakers regarding the issue of residual resistance. As the pile is driven. Because we have EDC, the residual -- static load has to be adjusted -- how is the residual stress issue addressed in making the comparison, especially if the phenomenon is expected to happen.

I will start with Florida.

Good afternoon, how are you?

Pretty good, how are you.

The issue with residual stress is something -- you have an option in EDC on whether you want to turn residual stress on our off. That will bring the measurements of residual stress to get from instrumentation. How exactly that is applied on the calculation, itself, I'm not sure. That something I think is a question that is post post to University or too Mark struck struck -- smart structure.

I'm not aware of how the algorithm brings that into account. I'm not sure it's that prevalent. It may be in some cases, for sure. I'm not sure that most of the time, for the type of pile driving we do in Florida, that much of an issue in and your experience. It may be different. I would have to attracted to the smart structures or clarification on that question. I'm asking because the good thing about CDC, you are able to get and separate the shaft and stress is not accounted for. Not distribution. Is no longer about that. It has to be adjusted to the rail distribution. To model the entire band, we need [Indiscernible] but it has to be based on [Indiscernible] if they develop, especially when you talk about bridges with [Indiscernible]. The shaft resistance is it true or not, the strength that you are modeling is true or not. I'm just concerned about it. [Indiscernible] effect of the load [Indiscernible]. That's why I'm asking that q uestion.

Sure. That's something that we can look into.

Thank you.

We will go back to the chat r oom. From initial. His first question was with regard to changes in specification and recognition of several advantages provided by tip gave censures. What are the changes being made to specifications regarding these advantages when you compare top only sensors and when will these changes be effective?

I will speak on behalf of Federal highways. Haven't really gotten there yet. The actual initiative is part of a deployment effort. Rodrigo, Florida has made some adjustments to specifications with regard to the use of EDC work maybe you can talk to those.

Sure. Buckley, Larry is sitting here with me. If I say something out of line, I'm sure you will hear from him. We have included EDC as an alternative for dynamic.

-- specs. There's no way for us to have something in the specification that says because EDC has tip gauges, we consider that to be an advantage and therefore we do this to address it. That has to be addressed through a resistance factor. The current procedure dollars AASHTO's methods being first order second moment, or more informed type approaches to developing the resistance factor. Those approaches do not have something built into them that says we have an extra level of accelerometers in there. This is how we bring that to did development of the resistance factor. That's not there. That something the University of Florida has looked into in previous years. How to bring in certainty from different angles, including data collected during piledriving. We are not there, yet. Yes, we have made changes to the specs in terms of bringing EDC as an alternative, a feasible alternative for dynamic load testing. However, we haven't made any changes to the resistance factor based on the additional level of instrumentation just because current practice is not there yet. Unfortunately, it's not there yet so we don't have any way to bring it in until the University develop something in AASHTO. We are where we are in that regard and EDC is currently allowed for use in Florida and its used under the same resistance factor.

Right. Because the way the resistance factor develops, the type of construction control and the frequency of that control, Florida has had to make some assumptions based on its restrictions results about high reliable but EDC has been for predicting resistance or verifying resistance in the state versus other forms of some construction control.

Is that correct?

Yes, Sir.

Kyle, anybody on the phone?

Next question.

This is a niche from Florida and I have questions, but just want to ask you on the phone line. What are the questions is with respect to design build projects and the DoD has money in different parts, [Indiscernible] for the gauges, not the contractor. DoD is paying for the CIA inspector and the contractor is paying for his own inspector. What if the contractor does not see and the incentive in using anything because of this money process and EDC is an additional cost for them. What project changes are the departments implementing to make it a leveling feet within the XML and PML Monitor gauge monitoring. When will this be effective?

I will ask all three DOT's to talk how you are addressing that issue.

In any order you like.

This is Ashton. I will give Rodrigo a break for second. I don't know -- I know we are not doing anything to do that. I don't really know that anything would be done in the future. This is a proprietary product. Obvious lie -- obviously, we can't just specify that unless it has some really significant difference or improvement that would justify its use. So, I think it's just going to have to rely on the -- over time -- with the contractor, with some contractors seeing a benefit to it and the only experience that I can offer is that Dominion Boulevard job that I talked about, that was a design build project.The contractor, himself, made the choice to do that. It was a fairly large project and there were three different contract piledriving operations going under different contractors at different times. The use of the EDC propagated through the whole project. So, having that experience with it, at least the contractors on that job thought it was beneficial and chose to use it for their project, as well. But, I think it's just going to take a experience like that. I really don't think -- unless we get enough information to say that having the sensor at the bottom of the pile, you will be able to use a different resistance factor, I don't see any changes made. The problem that I see with that, is the only way that's going to take place is through load testing programs. For our program, we are pushed so hard to stay on time and under budget. I can't do -- I've just got to go out into a load test that validates what we are doing. I can't do an experimental type thing that I could use to then take that information and.

Work with that. It's just do the load test, give me my production pie links and keep moving. At least in Virginia, I don't see us being able to have enough information to change our resistance factor is based on an information like that. That's all Virginia's got to say.

Mohammed or Rodrigo, anything to add?

We have similar situation with Virginia. We are still learning about it and will be very happy to change this time. We are working from the DOT of what they are doing and investing in now to improve the system and show some results and benefits we could use. That's the only hope we have.

This is Larry Jones with Florida DOPT. -- DOT. We've considered and discussed various funding mechanisms for using one system versus another. However, right now with the manufacturer of the pilot being the responsibility of the contractor, there is not really a way for the department to purchase something that needs to be put into the pile that the contractor needs to bring to the project working properly. There are various difficulties, where we are trying to iron same -- some things out, but we are not there, yet.

Okay. They had a quick question in the chat room. Can the PDA detect breaks near the toe? If not, why would we want to use EDC?

I will let Rodrigo quickly after that.

Sure. I didn't see that question. The answer is yes, it can. In fact, it does a very good job protecting pile breaks near the toe or the tip, because we had had instrumentation in that area. So, when we use only top-level instruments, -- I'm sorry -- when we are using top-level instruments only, the only way to address that or to assess that situation is by looking at velocity traces way about, way down and estimating wave speeds. We have the beta parameters. When you look at EDC data, you are going to have very clear indications that measurements are taken directly from near the pile tips, from those string gauge and accelerometers that we have down there

there. That think it does a very good job of predicting pile tip damage. I believe that was the question.

Yes. Okay. We have another question on the phone?

Once again, star one for any questions over the phones.

Next question.

Actually, my question was, can the traditional PDA system detect toe brakes?

I'm sorry, that was my fault.

That's okay. I wrote that down wrong.

If I can chime in. The answer is yes. It's a matter of how early we can detect it. What we've seen, is by having tip instrumentation, you generally have a little bit of a heads up. You get an early warning of possible damage that occurs at the tip. Like I said before, piles usually don't break in one shot. It's an ongoing process, cracking develops up to the point where you overstress the piling and it eventually crumbles or breaks. The tip level instruments in the EDC can detect that. When you use PDA, top-level instruments only, again, you have to go back and rely on your force velocity traces, way about, wave down in the beta parameter to estimate tip damage. It does a good job of predicting tip damage, no doubt, depending on where the damages. It's just that we've seen EDC tends to give us a bit of an earlier warning than beta.

I see.

I have another question, is that okay?

Yes.

A comment was made about the proprietary nature of the smart structure stuff. In my research at the industry, is of the PDA technology -- isn't that -- even though there's multiple tests companies using it, isn't that all based on the same proprietary technology from a single company? Or am I mistaken?

Maybe I will jump in on this one, just because I had this question come up several years ago. By us, specifically saying PDA or pile dynamic analyzer, that could be interpreted as, yes, we were requesting a sole-source service. We had a complaint from another firm that used the method that's used a lot in Europe. I think it's D&O. He complained about that. Our spec was changed to take out any reference to PDA or pile dynamic analyzer. If you look at -- and we used the ASTM spec to do that. It just -- the wording there -- it is not mandating sole-source, but maybe just because the way the American industry is set up, that's what we've been getting. Even though there were other was up there, we are not saying anybody come in and say hey we want to use that. Everybody sticks with what they are familiar with.

Also, EDC used to be s ole-source. No longer sole-source. Any company could acquire the equipment and run the test. The same as the PDA.

Bob, the name PDA, CAPWAP and EDC, the data collector, proprietary names. They would prefer that at state D OT, as well as Federal land officers use the testing they are actually requesting.

Let's try to attack some of these other questions in the chat room. Ricardo, if you are on the line, you might hit star one so you explain some of these to me. You had a burst that said what about 30 inches? Hollow piles and [Indiscernible] piles? Ice and the question is can the EDC be used on cylinder piles Iran steel piles?

We have piles -- the pile has 18 inches whole and 6-inch square and has 18-inch hole in the middle of it. They would be able to install the EDC equipment there. They could do it for a cylinder. I was told by Smart switchers, working for the steel, I'm not sure they are there, yet heard.

Any other questions on the p hone?

Next question.

[Indiscernible]. My question, this EDC, [Indiscernible] do you follow me?

Can you mute your computer speaker?

[Indiscernible] been on since 2000, if I'm not mistaken. I see your presentation and I thought a couple of things on it. First of all, all the testing that you do, EDC and PDA, [Indiscernible] with that, if that's the way to do business performing the static load testing. You said that you have [Indiscernible] in years that we have tested with PDA or EDC. Why we don't have more testing? Are you planning to do more testing in the future sponsored by DOT? Or has to be sponsored by the contractor. The contractor doesn't want to spend any money on it. Money is an issue. The second, when you showed your database and the results of the E DC, I couldn't see it [Indiscernible] being on it. Thank you.

For those on the phone who were caught up in the echo, the first question revolved around why we are comparing -- why the EDC is compared to the PDA and not the static load testing. I think that's correct. We will start there.

Sure. Like I mentioned before, we are in the process of collecting as much data as we can for static load t est. The recent static load test in Florida were done under a design build contract, where that particular team won the project partially because it included static load test and 100% dynamic testing, which eventually turned out to bring them some benefit in terms of pile length and driving time and all of that. Apparently, allow them to bring their cost down enough to win the project. So, we have not had to pay for every single -- every single study load test that we've done. Usually, we are trying to get money from the project to do the static load test. The contractor would not be affected at all. By us requiring a static load test on the project, because he would be getting paid to do the static load test. So, I agree with you that money is an issue. Otherwise, we would have a lot more results. So, it's moving slowly. You remember from the slides, this is an effort we started in 2009. Since 2009, we've been able to collect 18 static load test r esults. We would like that number to be much, Dr. Slowly, but surely, we are trying to get there.

Great. Not sure if you raised your hand on purpose in the web conferencing room. If you have, press star one and ask your question.

Is it okay if we take the next question over the phone's?

Yes, please.

This is a niche again. I have a question left with respect to the design build projects. It shows like almost all consultants, contractors had [Indiscernible]. Consultants for the business to make sure contractors use early PDFs on the projects. I think this is a conflict of interest. One thing I want to check, DOT looked into this scenario and if s o, what steps are being taken to have the level increased and what is the timeline, for the implementation of these steps.

This is ashen again. I will jump in on that a little bit. At least here in Virginia, almost all of our testing -- when you say consultants, I'm normally thinking of the design consultants. The design consultants that we have here usually -- they don't have any kind of testing capability. But we have numerous firms in this area that our specialty testing firms that are the ones for all these years have been doing PDA testing and some of them are buying in and offering the EDC as well. So, our contract there's -- when we specify dynamic testing, it's to be included. They will go higher one of those specialty testing firms. Really, it pretty much comes down right now to who is going to be the cheapest, still, unless you can -- if he do a load test, you get a little bit better resistance f actor, so that maybe the reason we do an additional resistance test. My position, is that I think I could could maybe shorten the panels up a little bit more. Is that the way the contractor and his design consultant or specialty firm are looking at it? I think, once again, we do have firms in this mid Atlantic area that are taking the training and are capable of providing both of the test. That's all from Virginia.

Thanks, Ashton.

We are now about five minutes past our allotted time. I will check to make sure there are no more questions on the phones.

We do have one more question. It's fine if you do go over.

I will take a question.

Kyle, your line is open. Please check your mute function.

Hello? Color, please check your mute function. We are unable to hear you if you are speaking.

We have no further questions in queue.

Okay. With that, if we don't have any more questions, I am going to go ahead and close this down. You'll notice we have taken the presentations away for download. We will have those posted on the AASHTO initiative website very shortly under the EDC topic. I I see one more question came in in the chat area. What is the wave speed on the EDC higher at the tip, on the EDC out put?

I'm not sure what you mean.

Ricardo, can use star one and come on the line?

[Indiscernible]

Rodrigo, my question is, out put from the EDC, the tip is higher than the velocity at the beginning. Do you think that the database you collect from the study of the test is enough? Enough to create some specification for the future of the EDC?

Let me go to the first question. I believe you refer to the wave speed at the end of drive. Not necessarily at the tip of the pile. They are using both top and tip instrumentation to estimate the wave speed per below. They are not estimating Wade -- wave speed at the beginning of the pile. It's throughout the pile for that blow. Occasionally, we have seen that increase or decrease toward the end of the drive. Keep in mind that that wave speed is provided as information only. It is not the wave speed used in the calculations of modules. Or, and any other calculations for stress or resistance. We've seen that parameter occasionally behave erratically, which doesn't really matter because it's not used at all. In general, it's provided relatively solid information about what may be happening with the pile whenever we believe that there may be some microcracks developing along the pile. It seems to do a good job at suggesting that occasionally microcracks may be developing. Hopefully, that addresses your first question. The second one, I believe it referred to -- excuse me, coming up with some type of specifications that result from the static load test. I'm not sure I understand the question. Do you want to elaborate on that? I wouldn't make any particular changes to the specification based on the result from static load t est. I don't know if you talk more about the particulars of how to drive the pile? If you can elaborate on your second question.

What I mean is simple. Your EDC, it's a proved system for the pile testing. We don't have the database to rely on that system for all the eight teen test [Indiscernible]. To create visibility in the EDC work the cause, we compare it EDC with PDA. I don't think that's a good idea. That's what the EDC is doing lately since the beginning. I don't compare with the idea, a compare with the test [Indiscernible] states.

This is Ashton. Let me jump in on that a little bit work let me preface it by saying that I'm about two years from retirement, so I've gotten a lot less timid the closer I get to retirement. The way I've looked at this, when we first -- when PDA testing first came out, we had those two big load test projects that I told you about in my presentation. I was satisfied from the results of those, that I was getting conservative values from the use of PDA from my projects. So, I pretty much bought into that 100% and although every now and then on a specific object, when we want to increase pile loads, we may do a load test. You do a lot of load test on drilled shafts, that very few on piles anymore, because, because we're so so confident with the PDA. So, I think the technology there has been proven. To me, I feel like what Florida d id, Florida showed a very good correlation between the PDA results and the EDC results. So, if I'm getting the same results from the EDC as I am from the PDA, I feel like it is an acceptable technology and once again, we are still talking about factors of safety, of over two or resistance factors of only one half. If I'm getting a 10% over or 10% under, I still have a good pile. That's what my thinking is in justifying the use of the EDC as an equal. That's all from Virginia.

Couple of items. The first one being the comparison to PDA. We've known about the reliability of PDA and PDA and its well-documented if you look into the [Indiscernible] 507, the work that Dr. Petoskey did, where its well-documented and the reliability of PDA is well documented it's not just an opinion. The numbers are out there. They prove the level of reliability of PDA. That's where the resistance factor of that in AASHTO came from. To compare a system against PDA, I think it carries a little more weight than you are assigning to i t. Keep in mind that we had a database in excess of 200,000 comparison points between EDC and PDA. Both the standard deviation and the average values are there for everyone to see. The numbers speak for themselves and we try to go a step further in that comparison to CAPWAP. I agree the comparison to static load test is better. But, like I mentioned before, we are in the process of doing that.

Okay. That's it for me.

Okay. There are now 15 minutes past the allotted time. I am going to go ahead and close this webinar on the embedded data collector. If you do want more information, you can reach any of the three presenters today from Virginia, Florida and North Carolina. We thank them. You can also visit the AASHTO novation an initiative at aii.transportation.org. I think everyone for attending.

This does conclude today's webinar. Thank you all for your participation. You may now disconnect.

[Event concluded]