As pervious goes, it has a lot to do with the variables involved in available materials and how they are handled. The recent history of pervious evolution has revealed certain unusual requirements in mix and method that differs from conventional concrete and in some practices, is completely opposite. Issues of permeability and density go contrary to every proven concept that is practiced in making structural concrete. Issues with water content in pervious concrete require practices that are opposite the typical precautions for conventional concrete. Numerous issues arise when pervious concrete is made with a dry batch operation in a transit mixer. Different issues arise for pervious pavement being built in a freezing climate and grave issues arise in dry and windy conditions. The ultimate message of this text is to explore the inherent differences between conventional concrete and pervious concrete. This includes the formulation of measures to address these differences with strategies for surviving the installation.

Safety is always important. However, this text includes absolutely no consideration for the safety of life or limb of the workmen or workwomen involved in the production or installation of pervious concrete. Wherever safety is mentioned, it is in reference to the safety regarding the perishable nature of pervious concrete materials. If this aspect of safety is ignored, the pervious concrete materials will not recover. Human resources are referred to as expendable or they may be advised to grow new limbs at any time during the scope of operations.

Wet Method The content of this text deals mainly with design and handling of pervious concrete being produced by a dry batch operation in a transit mixer. This includes consideration of the inherent limitations of the plant and mixer relative to quality control and performance of pervious concrete made in this way. Many of these limitations do not exist in operations using central batch, volumetric batch or lab equipment. The design, testing, production and handling methods proposed by this text are specific to what is called a “wet method”. This is a lighter mix, containing a higher water content.

The aggregate matrix is arranged and the way it interacts with the paste is very different in pervious concrete. Conventional concrete comes to placement, with the aggregate suspended in a medium of paste. In this condition, the large aggregate may only touch another in one or two places. Pervious concrete stands as a skeleton, with the large stone touching another stone in six or seven places. The paste must freely deform to allow stone to stone contact. With the stone in position, the paste reforms into the paste bridge that transfers load in the pavement.

Our first objective is to survive the installation and connect the aggregate to sustain a thirty year service life. Second, is the ability to resist freeze / thaw damage. Third, is to build the voids big enough allowing vacuum service to sustain permeability. All of these issues relate in some way to the management of water during production, installation and moist curing.

1.6.1.1 contractor certification tech, installer, craftsman

1.6.1.1.b Installer level instruction of the lab segment of pervious tech training. Includes a lab exercise to present different mix variations to the students. This would include playing with the effects of different paste moisture and different aggregate combinations. As the students examine the paste and mortar rheology and its effects on the void structure, they work in cups, with add water in a 6 gram syringe. I currently do it with a small, pre packaged ups shipment including the students batch and the teachers batch. The rest fits in a suitcase. The students batch (cuppo perv) is .02 cubic feet and the teacher has four batches, (meatloaf batch) each at .2 cubic feet. These are complete with aggregate separated into amounts holding in #4, amounts holding in #8 and the last is passing the #8 sieve. As well, the admixtures are included in vials and the fly ash and cement are examined by the students, on a tray.
The four meatloaf batches are mixed in a bucket with an electric drill, churning a paddle blade. The four variations of meatloaf batch include:
One that is 20% dvc,
One that is overloaded to the equivalent of 16% dvc,
One that is too dry,
One that is too wet.
The four batches are prepared ahead of time and are placed in meatloaf pans, troweled and edged and may be tossed back to the bucket, moistened and remixed. Students seem to get a clear understanding of pervious, having seen it and handled it in certain variations. It's even more effective that seeing a perfect demo. Better yet, show them both.
All of this is intended to be a reflection of generic pervious, a baseline mix which I believe to be our strongest contender for cost effective pavement systems. As one would consider more and better admixtures, I hope to separate those into another category called "value added pervious". I advise students to get a good, working knowledge of generic pervious before advancing into value added mixes. This base line mix design would be considered the object of the teaching lesson as well as the recommended starting point for more advanced admixtures and for more advanced users. I think this endeavor is worthy of due diligence.

6.1.1.c craftsman consultants, by Brian Lutey
Associations use the experienced and proven assets as consultants whenever possible.
I have never had anyone refuse the help of an experienced pervious specialist, and many have been happy to pay for their services when they see the value they can bring to a project: Increased level of success & better productivity on their first few jobs. An experienced consultant can usually double the installation rate for a new crew with better results. This not only helps the contractor make more money and avoid tearouts, it advances the market tremendously by making very successful projects out of what could be marginal or failed results without the help

1.6.1.1e Bid Consideration The options that include craftsman are preferred and their bid becomes more valuable to the owners of this pavement. The ultimate consideration in bid selection should be the body of work that is offered by the contractor. The owners or tenants should inspect the contractors previous work or the test panels they have done with the producer. No bid should be evaluated on its price alone.

1.6.1.1.e site hydrology & storm water percolation
One commonly misunderstood function of a pervious system is the perk requirement being stated as a minimum .5 inches/hour. This parameter is associated with the common configuration of 6 inch pavement on 6 inches of open graded, same sized aggregate. This is also assuming a given precipitation expected in a 24 hour storm event within the 100 year cycle. However, many options are available to realize the benefits of the pervious pavement stormwater management system. Mainly, the filtration function of the system will mitigate pollution and temperature. As well, the system can be designed to maximize even very low perk rates.
For example, a recent project in Carolina had soils perking at .02 inches/hour. With a slightly thicker aggregate detention basin, the system was still able to contain and perk 11 inches of storm water over the course of six days without discharging from the vents of the system.
It becomes more important for you position the elevation of the vents below the pavement slab, when the site is in freezing climates. This can be easily achieved by thickening the aggregate detention basin.

1.6.5.4 targeting moisture, by Brian Lutey
I am still constantly fighting against the insidious ‘snowball’ or ‘meatball’ test in my own market with testing firms and contractors; even the ACI pervious contest team that I worked with got online and found the ‘snowball’ test after I had given a presentation to them, and thus their samples were produced too dry and the strengths suffered accordingly.

3.1.2 The detention basins
are built to be level in the bottom and check dams are used to divide the basins into terraced elevations if the site is sloped.

3.1.7 Darcy columns
can be used to allow points for water to pass through clay soil. The Darcy column is set into place in a hole that will penetrate a layer of clay, to reach granular soils below. The pressurized outflow resulting from the elevation drop in the column will enhance the performance of the storm water system if built on clay soils that lack permeability.

1.6.1.1.f hydrology
Pervious pavement technology has changed rapidly in the past seven years. We came to learn a lot about this product when it became used in freezing and dry climates. The more we learn about it, the more it bears out the fact: This is very different from conventional concrete in almost every way. The ultimate objective is to know these differences and manage the risk to survive the installation, make pavement with a thirty year life cycle and serve the hydrologic function of the overall system.

1.6.5 Quality Assurance is the shared role of the producer and installer. Both must perform in harmony to address the unusual properties of pervious concrete. Production and installation are required to maintain the integrity of pervious concrete. Before the test panel is placed on site, considerable preparation is required to address the main threats to the concrete during production and installation. A bid submitted for pervious concrete pavement should be evaluated by more than the price of the bid. Careful attention is directed at the credentials submitted with the bid to evaluate the official pervious certification as recorded by NRMCA and the recorded history of projects performed by the bidder and associated workforce. Use extreme caution in the award process of the bids as the lowest price may come from a bidder without proper credentials or experience.

1.6.5.1 Unit weight, fresh plastic
Pervious concrete should be tested relative to two distinctly different type of mix design. Some methods of pervious installation pertain to heavier and drier mixtures which are not flowable and are installed with a two-step method. Referred to as two-step pervious or zero slump pervious, it is best tested for fresh, plastic unit weight with methods shown in ASTM C-1688.
One-step methods require pervious mixtures showing significant slump and flowable properties, with paste of significant lubricity. These are best tested for fresh, plastic unit weight with methods shown in ASTM C-138.
These types of pervious mixture show the one-step mix design to be lighter in both fine aggregate and cementitious materials and higher in water content and plasticity. This difference will realize a dramatic variation in the natural compaction and the ease of compaction of pervious materials in testing and in placement.

1.6.5.1 Unit weight, fresh plastic
Flowable pervious is more appropriately tested for fresh plastic unit weight with the astm C 138 using rod in three lifts, in a .5 cu.ft. bucket. Pervious mixtures that use near zero slump, would be tested with the astm C 1688. Some could dispute this disparity or may insist on using a .25 cu.ft bucket. The appropriate reply should include advice to “buck up”.

When the unit weight test is performed, pervious concrete is subject to errors, subject to the lubricity of the paste. Flowable pervious is made with paste that will aid the movement of aggregate as it moves together, into consolidation. Dry pervious will realize a loss of lubricity that changes into paste that resists the movement of aggregate position. This critical difference in the rheology of the cement paste causes a significant shift in the unit weight. The test needs to properly represent the material.

We find much more consistent measurement if we test it without the paste. This will not verify the content of the completed mix but it is essential for planning the mix. That includes the mix design that uses a “floating cementitious content”. This may seem to be a bizarre concept but it reflects the ongoing measurement of the aggregate supply. The test C-29A is maybe best understood by visualizing a cube of stone, with the same specific gravity of our aggregate supply. We know that if this cube of solid stone is exactly 12 inches on all sides, it would weight 168 pounds. We find the dry rodded unit weight of our bare, bulk aggregate is 101 pounds. We calculate, by percent, how much aggregate volume contains aggregate. As well, we know the rest of that space is our precious void structure. This available space must contain all of the paste and still have 18 to 20 percent voids. It is easier and more consistent to measure the bare, bulk aggregate and design the rest of the mix to stay within the allowable space. The main goof in pervious mix design is to add more components to the mix without staying within this allowable space.
It’s not a question of choosing one of these tests and ignoring the other. Pervious QC includes both types of testing. When all systems are working, both test verify each other. Changes in the aggregate supply can be detected and adjusted in the mix proportions, before this appears in the complete mix. Currenty, this ability to assess and target moisture is the art form that is learned only with hands on training. As the pervious concrete is handled and assessed for moisture, it must be done without fear of causing a collapse in the void structure. This judgment is made with careful attention to the rheology of the paste. If the mix design is not balanced, the installer will be forced to stay dry or collapse the voids. This act of retaining water is one of the main cause of failure in pervious. It is also the main cause of errors in the unit weight test.

2.2.1.c Aggregate size is selected based on the designed surface texture of the pavement. The predominant use of 3/8 inch aggregate in pervious mixes is chosen to serve pedestrian traffic and for ascetic appearance. Larger aggregate may be used if very coarse surface texture is desired. However, pervious mixes made with large aggregate are prone to segregate and are difficult to maintain a homogenous finished product. As well, coarse mixes are difficult to handle in screeding and compression phases of the construction. A smoother texture is

found in using ¼ inch aggregate but such aggregate often requires a reduction in cementitious content, and cannot be used if it contains excessive sand. The allowable sand content found in almost every aggregate supply is verified by the ASTM C29 test.

2.2.1.c aggregate selection

Variables in aggregate. As every aggregate supply differs, we become interested in the voids measurement to proportion the appropriate cementitious content. As we consider the effects of elevated fines, two issues are at play. Elevated fines will produce higher density, and higher strength. Also, elevated fines requires a reduction in cementitious content.

Recognize the limitations of making pervious with elevated fines when it relates to producing it in a transit mixer. Pervious mixes with elevated fines are more difficult to mix, slower to discharge and usually will not discharge the last half yard. If a pervious mix is designed too heavy (aka: elevated fines and excessive cementitious) the installer is likely to encounter a very typical hazard. Heavy mixes tend to run out of space for the free use of water. Don't be quick to presume 89 stone to be close enough without measuring the fines and the unit weight. While some are preaching, "add sand, taking it down to 38%", I disagree. I insist on freaking out if someone suggests that we add sand without bothering to measure it before or after. Take the natural supply of #89 and monitor the voids content. Constantly adjust the cementitious content to accommodate the variation, if any, in the aggregate supply. Avoid added sand to keep the mix conducive to production in a transit mixer. Even those producing this in volumetric equipment must give critical attention to leaving room for water. To add sand is to invite logistic snags in a critical chain of events.

2.2.5 Cementitious content is moderated to arrive at the installer's favorite design void content. My favorite number is 19 while yours might be exactly 17.5%, dvc (design void content). Here is where heartache begins, at about 15% dvc, you will be required to starve the mix, holding back water that is essential to this product, or you will entrap the voids. Microscopic images of pervious are littered with dead cement. Building pervious pavement in dry and freezing climates has brought us to recognize the importance of managing water and maximizing hydration.

I preach higher water and lighter mixes because it becomes a safer product to manage.

2.2.1.c Aggregate Shape, Texture and Absorption.

Crushed stone or natural gravel may be used in pervious concrete. Aggregate sources should be considered and evaluated, based on availability and market

price as well as performance based issues. This choice should be configured to the expectations of the client, specific to the function of the pavement. Pervious performs best with hard, heavy, clean aggregate.

Hard and heavy aggregate is a reflection of its specific gravity and absorption. The localized nature of aggregate markets and quarry facilities will not likely allow cost effective production beyond certain limits. Production on a scale less than a few thousand yards will likely be limited to aggregate that is being already used in the production of conventional concrete. Within these options, you may be able to source different options in aggregate size and gradation but you will not likely find much variation in specific gravity or absorption. As well, you will likely find either crushed stone or natural gravel; not both. To apply the real costs of transport and special handling outside this type of aggregate source could easily double or triple the price of pervious concrete within a particular area.

Some sources of crushed stone will produce slightly better strength in pervious. This is attributable to the clean bonding surface on the stone. As well, stone is more likely to have been properly screened with gradation remaining constant. The hardness and composition of the stone will affect the shape. Generally speaking, this ranges from a nice triangle shape to something that looks more like an arrowhead. The sharpness of the fractured edges will affect the consolidation of pervious materials and should affect the design void content of the mix by roughly one or two percent. The shape of the void structure is more intricate in pervious concrete made with stone as these fractured edges cause more and smaller passages in the structure.

Natural gravel from certain quarries is sometimes used in conventional concrete without need for washing. Also, it is sometimes handled without any attention to screening. While these aggregate handling practices may be thought of as “suitable” for conventional concrete, they must be more closely controlled for pervious concrete. Pervious concrete aggregates should be clean, with gradation controlled and constant. Pervious mixes made with gravel will consolidate more readily with the rounded edges easily sliding into place. Decorative, stamped and exposed aggregate surfaces are considered more suitable using gravel. Again, configure this choice around the needs and expectations of the client.

Blends of locally available aggregates may produce a superior aggregate for a pervious concrete mix than any single product produced for use in conventional concrete. Conventional concrete is designed to optimize particle packing to produce as dense and tight a material as possible, whereas pervious concrete design is targeting an open and drainable matrix of aggregate with sufficient support for its designed use.

2.2.1.e added sand

We are trying to influence the training programs for producers and installers of pervious with a standard, baseline version of pervious concrete. We want this to reflect the specific inherent limitations of pervious made with a dry batch plant in a transit mixer.
Unusual attention is given to volume and space in a fresh pervious mix and to the space within the bare, bulk aggregate supply. Techniques in materials testing for pervious concrete relate to matching the paste volume to the available space in the aggregate voids.
2.2.1.f Aggregate voids C-29
More critical issues are found and precisely tested with the ASTM C29A showing voids in the bare, bulk aggregate. This measurement of the allowable space in the aggregate drives what we have come to call a "floating cementitious content". The QC operations assume an entirely different role with pervious materials. This must include in ongoing measurement of the aggregate supply and preparing the aggregate to SSD condition. With this careful preparation, all of the other incredients are calculated for both weight and volume. This is done to target a specific void content to allow the free use of water.

2.2.7 Water
I believe the main issue that plagues pervious comes from problems with hydration. As conventional concrete is made with water of convenience, pervious is made with water of necessity. This includes a generous water content and a mix proportion that will allow it. Our objectives include supplying the hydration as well as shaping the paste. As the paste coating must deform to allow the aggregate to touch and reforms into the paste bridge, the highest strength is reached. This moisture content is also necessary to consolidate the matrix with minimal mechanical compaction. The intent of this combination is to make it a safer and more manageable product.
In our efforts to target the proper water content, we find that heavier mixes have no forgiveness in tempering the load onsite. My contention with heavy mixes is that they are commonly starved for water in fear that the voids will entrap as the mix collapses into placement. There is a certain sweet spot that is reached when the rheology of the paste reaches a certain lubricity, allowing the materials to collapse and bring the aggregate faces into contact. If the aggregate is separated by cement paste, the strength drops.
Without much variation, our group contends that bulk aggregate voids should be kept between 38 and 41 percent. If that becomes too low, we should seek a different aggregate source or add coarse agg.

2.2.1 Aggregate selection, small, architectural pervious
Squeegee is a slang used in some regional markets among rocky mountain hillbillies. It is usually thought of as a waste product from ready mix aggregate that contain excessive amounts of certain sizes. Depending on the agg quarry, this can produce mountains of sizes that can be suitable for pervious. That is to say it can't have a lot of the smallest fines. Mountain folk call some of these

sizes, “pump cloggers” and “trowel busters”. Good, huh. Almost as good as those ohio river hillbillies.,

2.2.5 Cementitious content is limited by the measured available void space of the current aggregate supply. As this void volume varies, the cementitious content must be adjusted to target a specific void content in the product. The total volume of cementitious paste must be moderated as color pigments or other volume is added to the cementitious paste. The main intent of this close attention to void content is to allow enough space in the matrix of the void structure for adequate water content. Without this critical balance, the void structure will entrap and the hydrological function of the pavement is lost.

2.2.5 The minimum cementitious content requirement is the single biggest goof in the ready mix production of pervious. This cementitious content is entirely driven by the measurements of the aggregate. To effectively market pervious materials, one must work with the agg that is already in the producers operation. As we measure the void content of bare, bulk aggregate in most operations, we need a total cementitious of 530 lb..
If special aggregate is sourced, handled and made available, higher amounts of cementitious are suitable, up to 630 lb., with perfect aggregate. That is, single sized 3/8 in., with zero amounts passing #4 sieve. I am quick to point out that it makes no sense to use such aggregate. Our natural marketing scenario almost always requires the ability to order concrete at will. It also requires us to include certain unusual steps in QC that are not normally done. The unit weight of the aggregate supply is continually updated. The voids, calculated from that unit weight, drives the floating cementitious content. That is to say, the mix is built with a voids target. The variations in aggregate voids requires an adjustment of cementitious content to remain constant in the voids target.
This is entirely too complex to fit into the one liner that you need for part 2.06A.
The bulk volume of aggregate per cubic yard shall be equal to 27 cubic feet when calculated from the bulk, dry rodded unit weight, determined with rodding procedure in three lifts, according to the ASTM C29a.
The essence of the difference in cementitious content and the difference in the agg batch weight is all about water. We are unable to use the water in balance with the cementitious content if the mix is overloaded. As we come up to proper water content, the void structure begins to entrap and loses flow. We need this void space to stay open as we freely use water.
We also need the voids to consolidate uniformly and this brings the aggregate back to the same density as the bare agg was measured, or within 3%.
The unmanageable traits of a mix that is starved for water, will cause a chain of events that ultimately puts the material at risk from a number of threats.

2.2.7 As pervious theories go, they range from a dry method, to a wet method. I have always favored mixes and methods that use a lighter and wetter process. The methods that use heavier and dry mixes have always seemed akin to RCC process. As the dry process is done in wet humidity and is never frozen, some presumed that more cementitious is better and drier concrete is always better, right? No!

Pervious came into use in freezing climates and dry climates with mixed blessings. As we pick through the remains of disastrous results, we find that pervious encounters a significant threat to hydration during production and installation. Microscopic slides of pervious samples are littered with the remains of dead cement. They also contain shrinkage cracking on a micro scale. We find that pervious with low water content absorbs too much available storm water in the course of service and suffers badly from freeze/thaw trauma. There are many among us who prefer the wet method with three main objectives.

Survive the installation. Coat the aggregate with paste that will deform and reform the paste bridge, maximizing hydration, and connecting the aggregate well enough to sustain a thirty year service life.

Resist freeze/thaw. Build the paste consistency to a full sheen to enable the void structure to readily drain out and avoid excessive absorption into the cement paste.

Sustain permeability. Design the system to reduce contamination sources. Build the void structure with enough volume to enable maintenance service.

I would be among the first to abolish the dry method but that would be a mistake. We should teach the theories and methods of both. As well, we must teach the limits and advantages of both. I know that the wet method is a safer product to produce and install, particularly in dry and freezing climates. However, this does not mean that there is no place in the market for the static roller and plate compactor.

I have done my best to track down all of the craftsmen as well as the producers. I have tried to force feed them and help them use lighter and wetter mixes. I have scanned through their toolboxes for nuggets of genius and moved on. This has acquired me a toolbox of my own and something else I had not anticipated. I acquired group of generous friends that is bigger than the toolbox. I feel compelled to share with others what these generous people gave to me. I want to avoid trampling on intellectual property but still share the essential parts of what we have learned.

We can enhance a pervious mix design with various admixtures but teaching pervious should be done with a “generic pervious” mix design. In pursuit of consensus, we should consider what minimum admixtures would be used to stand alone and would be used as a starting point to include “value added pervious” mix design components.

I have often said at the end of a perfect live demo with a perfect mix, Y’all must know that I’ve let you down here. As sweet as this is, you have no idea how

awful this product can be. You should teach this material in various forms of malfunction to illustrate how to recognize trouble.
I like to throw around terms like “Real men are judged by their water/cement ratio.”. Or, “Friends don’t let friends add water.”. To illustrate a point. Pervious is made from a very different type of water than conventional concrete. While conventional concrete is made with water of convenience, pervious is made with water of necessity. Pervious materials require much closer attention to manage water in all forms. Batch water, added water and airborne water are controlled and protected as it solves almost the entire scope of threat to this type of pavement.

2.2.7 I think that most people would be surprised to realize just how low their cement hydration rate is. In most of the cases of structural failure or surface failures (not clogging related failures), the hydration rates are extremely low. Collectively speaking, the industry is wasting more cement then they’re successfully using. I want to continue my crusade to get people to maximize the hydration as well as keep the voids uniformly interconnected. This attention also brings us to realize a valuable benefit when it comes to surviving low humidity installation and service life in freezing climates.

2.2.7 The job in Denver has such significant impact on marketing efforts in freezing climates that it’s in the best interest of us all to see it finished. As for NRMCA, you are in a particular jam because we all need the training to continue with even more intensity. We have learned a lot of things in the last three years about handling pervious in dry climates and Colin has a huge task of bringing these into the training. This is made tough because so many differing views exist. Most people consider the failures in Denver to be caused by freezing. Indeed, freezing is what finished it off, but the hot water pervious was doomed in the cold, dry conditions. The cement paste dried up before it could attain significant strength. Water fills the micro shrinkage cracks throughout the paste and the freeze does the rest.
I am sure that the contractor took precautions to cure the pavement but the extreme conditions demanded more. The scheduling forced the contractor into some of those extreme conditions beyond his control. Honestly, the blame lies with everyone who was absent from the pre-con meeting.

2.2.7 I believe that a lot of the certified technicians would do just fine, as is, if they always got a good mix. Most of them don’t recognize good from bad, following the recommendations of the producer who treats it like conventional crete.

While I risk boring everyone by saying the same message, I want to say this in a different way. Our problems are all linked in some way to the use of water. Anyone who is selling pervious without the skill of managing water in this product is in a very risky position. Our need for water is mostly twofold.

The paste must contain enough water to bring a certain rheology to its consistency. The critical function of this is to allow the agg to slide together with uniform consolidation with aggregate touching other aggregate on all sides. The paste must get out of the way as we seek a point to point contact in the aggregate. It is also necessary to shape the paste coating that is able to deform and reform into the paste bridge. The shape of this paste must exhibit apparent surface tension on the paste. The paste surface should shed water rather than absorb it for freezing climates.

The paste must contain enough water to supply the hydration chemistry. Conventional concrete is made with water of convenience. Pervious is made with water of necessity. The water batched in the mix, the water that is added to temper the load and the airborne water are all critical to the hydration. Successful hydration defines the winners from losers, especially in dry and freezing climates.

In 1988, when pervious was getting underway in Florida, they were making leaner and wetter mixes. During the years that followed, the pervious mixes were loaded up with cement and admixtures without regard to the critical differences required for pervious. I think this was done because that's what we do with conventional crete. However to design pervious without regard to the limits of the available space in the aggregate supply and simply add more stuff is a significant goof. It is also the most prominent goof in the use of this pavement.

The toughest part of marketing pervious is the reputation for ravel. Even in freezing climates, this is traced back to a malfunction in hydration. To overcome this, the producer and installer need the free use of water. This is not possible without measuring the aggregate and moderating cementitious to allow the space for adequate water.

Different people will choose different target numbers in a mix and I can predict some head banging about what those numbers should be. I put out a mix spreadsheet that can be downloaded from bunyansprings.com , which calculates the weight and volume of the mix components, starting with C29-A bulk DRUW from the agg, done in 3 lifts and 25 rods each.

If the agg voids calculate out to 39% or higher, you can expect the tasks of mixing and discharge to be much easier. Excessive fines and excessive cementitious can often bog down the placement operation to a snail's pace. Round, natural gravel should be calculated to a full 20% voids in the finished mix. Crushed stone should be dialed in at about 18%. If the mix is designed with enough space in the voids, water can be used without fear of collapsing the voids.

Strength testing does not indicate the performance of pervious concrete. We find a much better indication in the hydration count. While we are unable to bring this hydration up to 100%, but we know that hydration as low as 20% to 40%

represents a serious goof. As well, we know that our objectives are about managing water and hydration.

We could write warranty language about how to identify blame if the client's expectations are not met. But, I don't believe you can ever separate the producer from the installer in their shared roles in this product. That's why they are best presented to the owner, joined at the hip. That is to say, the producer stands with the installer, conducts QC, assures the integrity of the installation and has power to stop the placement if it's not right. Together, they warranty the flatwork. They can do this because they have done the homework, taken the precautions and they work together in harmony. This requires a producer with a select group of installers for this comfort level to work. It makes a world of difference to the client.

I wrote some recommendations to Colin about the training and I stopped myself short of irritating many in our ranks. But, I'll go ahead and say it. You can balance and temper a mix to a degree that it is safe, reliable, predictable, quick, profitable, and trouble free. If this is not done, it's best to deploy RCC equipment and method to properly install an unmanageable mix.

3.2.1 A granular subgrade is sometime used and referred to as a "choker course" intended to provide a finer filtration media below the detention basin. Some would argue the usefulness of this design but if used, use caution in placing the upper layers of aggregate to avoid disrupting the placement of fine, lower layer of subgrade materials. Vehicles delivering the detention basin aggregate can easily dislocate the subgrade.

3.2.3 Detention basins, if any, should be composed of uniform sized aggregate conforming to ASTM C33 and containing a minimum of 36% voids as per ASTM C29 procedures.

3.03B Mixing: Pervious concrete shall be produced in central mixers, transit mixers or in volumetric mixers. The manufacturers of mixing equipment will specify mixing speed and revolutions to produce a homogenous mix. Transit mixers require 70-100 revolutions or more, depending on the drum design. The Contractor will approve or adjust the moisture content of each load of pervious concrete and evaluate the homogenous uniformity of the mix.

3.4.d Hydration Stabilizer is required if production, delivery and placement requires more than 60 minutes to complete.

Water~~~~~~

3.4.c water

I think your experience with pervious concrete pavement indicates that you are struggling with a heavy mix. The main indicator is that this mix is constantly between too much water and not enough. As a pervious mix is designed, it is critical to leave enough space in the void structure for sufficient water. As many

would presume that the problem is excessive water, it is in fact excessive paste and sand that limits the space for water.
One of the confusing things about pervious terminology is “air”. Conventional mix design software usually states the air and the voids, collectively as entrained air. The actual entrained air is contained within the mortar and we are unable to test for entrained air because of the other voids. Those are the entrapped voids and the interconnected voids.
The void structure must remain as open as 20% for a number of reasons:

Enough space for sufficient water to supply hydration chemistry.

Attain enough lubricity in the paste that it will deform to assist the consolidation of the aggregate.

Attain enough surface tension in the cohesive paste coating to reform into the paste bridge surrounding the point where the aggregate actually touches other aggregate.

Leave enough open space to allow vacuum service to sustain the pavement permeability.

There is a sweet spot in the water content of the paste that is driven by its rheology. I call it “shaping the paste”. The paste will either aid the movement of aggregate into its original bare bulk volume, or it will resist the movement of aggregate. If this point is reached, the placement volume and the tested volume will remain within two or three percent of the exact volume calculation of the mix. This “sweet spot” exists with the paste still firmly clinging to the aggregate. However, the desired void structure will disappear at this point if the proportion is too heavy. In other words, there is not enough room within the measured void space in the aggregate to accommodate excessive fines, excessive cementitious and still have enough room for sufficient water.
At this point, the producer will often proceed with a fatal act, withhold water to avoid loss of permeability. This usually sets into order, a chain of events, when carefully examined, will show the concrete did not survive the installation.
It is an unnatural act for a producer who has made structural concrete for decades to begin compromising the structural integrity of the pavement with voids. They have generated habits of increased cement and reduced water as effective ways to improve their mix. They often influence the mix design, seeking a design void content near 15% and hold back water. When the placement density will not consolidate, they add more cement and add more sand. This makes the water management task very near impossible for the installer.
It is not uncommon to find troubled pervious with hydration rates as low as 20%. Having wasted 80% of our cement, our objectives are clear. Manage water in all forms, within the original batch, with the water used to temper the load during placement and the water that escapes from evaporation…dcmit.

3.4.c Wet or dry?

Jim, there is clear evidence that the absorption of the aggregate affects the durability of pervious in resisting freeze thaw damage. I believe this same concept applies to the absorption of the paste. One of the objectives in running

lighter and wetter pervious mix is to shape the paste with a surface that will readily drain out storm water. If the paste has been starved for moisture, the paste will absorb excessive amounts of storm water. This condition will also sometimes generate micro cracking in the paste that wicks full of storm water with each exposure.
I have attached two images of pervious that show extremes of this condition and another image of micro cracking.
While all of this attention to adequate moisture is important to all pervious, it is more pronounced in pervious concrete pavement that is subject to freeze thaw, particularly in dry climates.

3.4.c water
I think your experience with pervious concrete pavement indicates that you are struggling with a heavy mix. The main indicator is that this mix is constantly between too much water and not enough. As a pervious mix is designed, it is critical to leave enough space in the void structure for sufficient water. As many would presume that the problem is excessive water, it is in fact excessive paste and sand that limits the space for water.
One of the confusing things about pervious terminology is “air”. Conventional mix design software usually states the air and the voids, collectively as entrained air. The actual entrained air is contained within the mortar and we are unable to test for entrained air because of the other voids. Those are the entrapped voids and the interconnected voids.
The void structure must remain as open as 20% for a number of reasons:

Enough space for sufficient water to supply hydration chemistry.

Attain enough lubricity in the paste that it will deform to assist the consolidation of the aggregate.

Attain enough surface tension in the cohesive paste coating to reform into the paste bridge surrounding the point where the aggregate actually touches other aggregate.

Leave enough open space to allow vacuum service to sustain the pavement permeability.

There is a sweet spot in the water content of the paste that is driven by it’s rheology. I call it “shaping the paste”. The paste will either aid the movement of aggregate into its original bare bulk volume, or it will resist the movement of aggregate. If this point is reached, the placement volume and the tested volume will remain within two or three percent of the exact volume calculation of the mix. This “sweet spot” exists with the paste still firmly clinging to the aggregate. However, the desired void structure will disappear at this point if the proportion is too heavy. In other words, there is not enough room within the measured void space in the aggregate to accommodate excessive fines, excessive cementitious and still have enough room for sufficient water.
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3.4.c water & rheology…notes to industry pros about Matt Offenberg presentation:
With the stroke of a microphone, you killed the meatball (or snowball) that we have grown to hate. And, your other hand held a slump cone, advising a sizeable and moderate slump is pure genius! This move toward lighter and wetter mixes could completely turn around the reputation of pervious pavement into a safer product.
Many of the presentations caused me concern as they presented data showing a broad variation in consolidation, top to bottom within the pavement section. This single breakthrough could change this characteristic in pervious concrete pavement in a big way.
I was able to detect a will toward closer attention to the use of fine aggregate and aggregate measurements in mix proportioning. Rah!
You issued a list of challenges to the industry regarding other unusual and inherent properties of pervious materials. Once I regained my composure and could stop cheering from my seat, I wanted to add another challenge to the list. I want someone to produce a cheap evaluation test for successful hydration, to be taken at the placement inspector's selected location. My investigations indicated this could be done with in situ x-ray equipment but I beg to know if there is some other, better way. Successful hydration seems a better way to evaluate pervious, rather than strength testing.
We trust you to be a good influence on the 522. I speak for many when I say thanks for this progress from y'all…dcmit.

3.4.f Delivery: Pervious concrete may be delivered directly from the mixer or delivered by means of conveyer or buggies as close as possible to final position.
3.4.a The Contractor shall provide equipment to place the pervious concrete. Internal vibration shall not be permitted. Placement procedures shall utilize mechanical screed equipment such as a motorized roller screed or a vibratory truss screed. Hand screeds are prohibited except in confined and small areas.

Hand compaction tools are also used in such areas to compact the pervious concrete to proper density and elevation.

3.4.g Re: belt placement

Belt placement can be used to deliver concrete where transit mixers either cannot reach or cannot deliver fast enough. This would seem to be the answer for the ability to place as installers would use a concrete pump for conventional concrete. This is true in some ways but certain limitations apply.

Machinery condition is critical to certain quality control issues relating to pervious concrete. The condition of the belt itself as well as the condition of the cutting surfaces that clear accumulated paste from the belt surface must be serviced and in good working order. If conveyor machinery is used on large, coarse aggregate which has beaten and worn the cutting edges, it is best to make other plans or wait until the machine can be serviced.

Most of the systems that are being used, consist of two belts. The main belt will pivot and telescope. The feeder belt brings the concrete from the transit mixer up to the pivot point. Normally the conveyor machinery and the transit mixer are parked on about the same elevation. Plan the placement to allow the mixer to discharge from a position that is level or higher than the conveyor equipment. If the mixer is positioned to low, the belt is at too steep of incline for pervious. As well, this feeder belt must be run slow enough to prevent excessive amounts of concrete tumbling backward on the moving belt.

If you ignore these precautions, you can find a lot of the paste will collect on the belt and splatter it all over the pivot point. This mess and cleanup is bad enough but our main concern is that much of the paste is missing from the coating on the pervious aggregate. Also, the paste will collect in lumps that are found laying on the surface. The lumps are only an ascetic problem. However, our main concern remains that the paste is not arriving in the right place during the course of this delivery method, as described.

If these precautions are observed, you can come very close to replicating the performance of a pump. Other useful pointers would include:

Target the moisture slightly wetter as you stage the arriving mixers. The concrete is flying through the open air for much of the journey over the belt before it falls finally in place. This becomes more significant if you have weather alerts including wind or humidity problems.

Don’t limit yourself between the use of a belt and tailgating the delivery, simultaneously. In fact, it is one of the tricks to maximize your delivery rate.

Whether you look at it as square feet of cubic yards, both placement methods are going to hit snags. They are empty or they’re in the way. They need to move to a new spot or someone else is in the way. Or, damn, we’re out of mud again. Or, all of the above!

Slabs in bay configuration can be placed as acreage if the logistic snags can be overcome. Place directly from transit mixers and aid the placement with a belt by placing half of the bay, side by side. When the mixer runs out, spread out to full width until another mixer can actually start discharging. Meanwhile discharge at will from up to three other mixers parked at the feeder belt. If mixers become

scarce, look for a chance to tailgate the delivery and move the belt. A point to remember is that the game of “leap frog” should only be played among friends and make sure the batch plant is on our team and up to speed.

3.5.6.1 Screed and mix configuration, by Brian Lutey
We get all of our compression from the Bunyan Striker Tube and the fluidity of our mix, so we do not have additional compression with the cross roller and don’t have problems with roller marks as is the case with other motorized roller screeds, followed by the heavy cross rollers.

3.5.6.1 Motorized Roller Screed Construction. Pervious concrete is manually compacted at the edges during placement, prior to screed operation. The motorized roller screed is supported by edge forms and powered to spin counter to the direction of travel. The counter-rotating steel tube is drawn over the slab surface to strike the surface elevation and compress the surface materials. Screed rollers shall be minimum 6 inches in diameter and capable of configuration to a weight of 37 pounds per lineal foot. Strike-off is followed by cross roller tooling to apply mild compression and uniformity to the surface materials.

3.5.6.1 The ingredients are tallied for weight and volume as a means to adjust the critical targets of the design unit weight. As the design unit weight is compared to the fresh, plastic unit weight, it should remain within three to five percent, if the paste is sufficiently lubricated. However, you can expect the fresh plastic unit weight to go nuts if the mix will not flow and consolidate. The mix calculator that I have been circulating is more about managing the mix components that affect the water/moisture management than predicting the density of the finished product.
I want to take issue with the presentation of motorized roller screeds in your text. I see them lumped as equivalent in the ability to both strike and compress. The prescribed thickness for added shim elevation varies greatly between different manufacturers of motorized roller screeds. While I’m not anxious to point out critical issues of performance dynamics, it’s important to know that weight, diameter, slope and metal composition will all greatly affect the choice for screed elevation. Smaller diameters are only suitable for squeegee mixes and should otherwise be used on shims of ½ or more and followed with a static roller. Bunyan screeds configured with suitable ballast will run on a minimum of 1/8 shim elevation when used on conventional concrete or pervious. Any additional shim elevation requirement for Bunyan equipment would then be based entirely on the mix design. If your mix is a bit heavy or tight, it’s likely the ¼” shim language is good.

3.5.6 motorized roller screeds

Brian responded with points of compression and overweight cross rollers, done by the baby bunyans…quotes not mentioned here.

Indeed. The class of equipment that I've heard some people call "baby bunyan", is deficient in the compression function, for various reasons. That drives my advise that baby bunyan counterfeits should be run on the same shims and the same static roller as the vibratory truss screed. Attempts to achieve compression with an extra heavy cross roller, to me, equates to using a sod roller. It's too narrow for such a heavy foot print.

I have always felt that there needs to be some barriers to entry for contractors to install pervious. When at the IRMCA we instituted the Certified training requirement but at the behest of the Head of Indiana Stormwater, we also instituted a three strikes and you are out revocation of the certification. We only had to use it once, when an Indiana contractor who had been revoked got a job in Ohio, they checked his certification and saw it was revoked. They made him hire a consultant for the project. He came back to Indiana with his hat in his hand asking to get his certification back. Though we only used it once, it makes the rest of the contractors take the product more seriously, especially after they have had their first strike and they are reminded that they could loose their certification. We (Ozinga) still make this a mandatory for all of our customers. They sign an agreement to this effect when they take our test. The other policy that we had in Indiana is that we don't *ban* any other equipment, as long as it has been *proven* in our market. We had horrible results the few times we allowed untested equipment to be used on real projects. We have worked with Somero to improve their 3D laser head for pervious, and with some customers with Assfault paver machines to adapt them and our mixes to work with those machines, but we did not do this on real projects. We feel strongly about the Bunyan because we spent months initially working with Dave to make adjustments to the rollers, and found that it works with every mix design and aggregate that we have tried it with. It is the only equipment that I have never seen *cause* a problem with a pervious placement. With as many variables that can possibly lead to problems with pervious concrete, my goal is to eliminate as many as I can. We are still testing new placement methods and other materials, but we do so in non critical placements, so we don't show our dirty laundry. The assfault and porous paver guys will make hay with any failures that are out there, and we are also guilty of spreading news about each others failures as well. I encourage this in a *controlled* environment so that we can learn from one another's mistakes and avoid repeating them.
In my opinion there are too many contractors or admixture salesmen who install a project in a market and then leave for other markets with little or no concern for how well the end product performs. Villanova's courtyard and Walmart in Texas come to mind. NRMCA had to come to the aid of both of these owners to protect the product reputation. Unfortunately, they can't catch every one of those, so the State Associations and the local suppliers need to maintain higher standards.

We have had our experiences with the fly-by-nighters in Indiana and are now seeing some in Northern Illinois. I think that the Ready Mix Producers need to be the “Adult Supervision” when pervious projects are being bid and installed, and not allow chemical suppliers or equipment manufacturers to do their R&D on real projects. Do the experimenting in the back of the boneyard where you can make it disappear when problems occur. Learn from the problems and try again, and only take new technologies to the public when the confidence level is high. I hate to see the “Johnny-come-lately’s” who did not help grow this business early, come in and ruin the market just when it is starting to grow.
If a contractor is not willing to invest $8000.00 in a tested pervious placement system, is he really serious about the product? I highly recommend that producers who are serious about pervious concrete promotion get a rental system, or two to help nudge your better contractors into using equipment that is proven to work. Once they use it and see the market for pervious, they will invest in one for themselves.
If you can dial in your mix design, train your contractors, make sure they are using the right equipment; the next step to success is using The Bean as a secondary curing sprayed on just before the plastic is rolled out. This will prevent some evaporation before the plastic is put down, and is there to provide better curing even if he plastic is removed prematurely.
Brian

3.5.6 strike-off, shims & overbite

Brian, a certain, tiny bit of “overbite” occurs from the dynamics of the face of this tube, scratching against the agg. So, when striking on a cold slab, you should be up an eighth, to get an exact match on surface elevation. When configured on formwork, we concede that we aint building pianos and we forego the shim entirely. Some say we are not building pianos against the cold slab, either. As the new slab comes to be a reflection of the guides provided to the tube, we consider elevation match as well as flatness in this provided elevation. If you are running on a cold slab that has wild elevation, you should run on a screed rail that will bridge between the high spots of the cold slab and provide the tube with a straight guide, and configure the tube with a neck fixture. Usually this works best with a 2” square bar, sitting on the cold edge. If you are using a skate that holds the tube cold end, riding on a curb, you may want to rest some kind of rail on top of the curb to keep the elevation guide from riding on something with wild surface elevation or flatness.

3.5.6 motorized roller screeds

I would explain the limits of motorized roller screed diameter to directly relevant to the ability to compress, rather than strike aggregate of specific size. A motorized roller screed with a diameter around four inches would work nicely on ¼ inch aggregate. Whereas, the same diameter would tend to strike too aggressively with 3/8 aggregate, leaving the surface without sufficient compression. This condition should be used with full shims and followed with a full width compression roller, consistent with the use of vibratory truss screeds.

Avoid compensating with overweight cross rollers, as these produce the same results as the sod roller, lumpy and marked. We have been playing with motorized roller screeds for thirty four years and you could say there is more than meets the eye. We can configure this screed to bite off the nastiest crete you can get out of the mixer. But, this process can be made reliable and easy with some attention to the mix.

3.5.6 strike-off

A different approach to pervious has been used that is termed as a “one step” process. This was developed through the extensive efforts of the Indiana Ready Mix Concrete Assn. people, mainly Mr. Brian Lutey. The essential component of this method is the mix design.

It’s called “no fines” concrete but in reality, some fines are typically present in almost all sources of aggregate. No pervious mix should be written without knowing the ssd, dry rodded aggregate unit weight, bulk specific gravity and gradation amounts passing #4. These are used to determine the void space available for the components of the paste. Cementitious materials should be limited to maintain the void structure as well as maintaining an optimum paste coating thickness. I call this “balancing the mix”.

Producers often presume that more cement will increase strength. In fact, excessive cementitious materials will compromise the strength because it interferes with the point to point contact between coarse aggregate.

A balanced mix will allow enough water in the paste without closing the voids. The structural connection of the aggregate depends on a certain moisture content of the paste. As well, hydration requires a certain amount of water. Pervious materials have a w/c ratio that is dangerously low. A mix that is low on water or has launched hydration or has evaporated is doomed to ravel. We find it safer to install pervious with the highest water content that will remain as a stable, firm coating on the aggregate, with apparent surface tension. This cannot be done when the installer is afraid of closing the void structure with water.

We also find it safer to limit the time that the surface is exposed to the open air. The training suggests a time limit of twenty minutes. We suggest that sheeting should be installed before the sheen disappears and evaporation should be inhibited with soybean based curing compound. Unless the material is batched on site, high doses of hydration stabilizer should be used, based on ambient temperature.

A two step process including riser strips and static rolling often exceeds a safe exposure time, sometimes most of an hour. We use the Bunyan Striker followed with cross rollers and reduce the exposure time to three to five minutes. However, this requires a balanced mix with sufficient moisture. If the mix is too heavy and too dry, a two step method should be used, regardless of the screed equipment. If the producer insists on using aggregate that he has not measured, in a mix simply cut and pasted, he should understand his limitations and risks.

Significant attention has been given by NRMCA to training the installer without any help offered to producers. Bunyan offers help without charge to encourage a certain teamwork between producer and installer.
A mix that is suitable for a one step method should not be vibrated and should not be tested by jigging as rodding is more consistent.
I am reluctant to share too much specific information about the compression process that is done by the Bunyan Striker. I have a small parade of thieves that follows us around, copying our equipment. It's important to recognize that other roller screeds do not perform this compression properly. The performance of the Bunyan Striker should not be judged by the results of counterfeit equipment.
The one step method has been used because of the high success record and it's easier and safer to install.

3.5.6 Motorized Roller Screed. A minimum 6-inch diameter steel cylinder that spans the width of the section placed and exerts at least 15 pounds per lineal foot on the concrete surface. The Motorized Roller Screed is powered to spin counter to the direction of travel to strike off surface elevation and compact the surface.
3.5.6 Compaction is achieved with the motorized roller screed. Continued seeding and restriking is performed with the motorized roller screed to achieve uniform surface elevation and surface compaction. Additional mild compaction is performed with the cross roller to finish the compaction process. All other compaction measures are performed during delivery, prior to deployment of the motorized roller screed.

3.5.6 Motorized Roller Screed Compaction Gauge.
Motorized roller screeds use a cylinder that is powered to spin counter to the direction of travel. This equipment rides on formwork and strikes concrete as the face of the cylinder travels over the surface. Four main variables in the specification and configuration of the screed will affect the compaction force applied to the surface of a slab of concrete of specific coarse aggregate.
The relative proportion between cylinder diameter and coarse aggregate size affects compaction intensity. A small cylinder will contact large aggregate and strike it forward rather than pressing it downward. Pervious concrete pavement placed using the one-step method (without additional compaction from full-width static rollers) requires the screed to achieve 80% of the compaction task. The remainder of compaction is achieved with cross rollers after the screed is finished.
The weight of the motorized roller screed must be configured to avoid riding high or skipping over concrete that is above slab elevation.
The hardness of the metal of the screed cylinder affects the compaction force as softer metal is prone to strike rather than compress surface materials. Higher carbon steel or stainless tubing is preferred for higher compression.

The speed of the cylinder rotation must be sufficient to pass at least 4500 inches of cylinder surface over the slab surface, per minute. This provides sufficient uniformity for pervious concrete placed in one-step operations.

Coarse agg size, inches	Cylinder diameter, inches	Rotation speed, rpm
¼", 0% retained on 3/8 sieve	4	360
¼", 5% max retained on 3/8 sieve	4.5	320
¼", 10% max retained on 3/8 sieve	5	288
3/8", 0% retained on ½ sieve	6	240
3/8", 5% max retained on ½ sieve	6.5	220
3/8", 10% max retained on ½ sieve	7	205
½"	8	180

3.5.6 screeds, by Brian Lutey

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the “Adult Supervision” when pervious projects are being bid and installed, and not allow chemical suppliers or equipment manufacturers to do their R&D on real projects. Do the experimenting in the back of the boneyard where you can make it disappear when problems occur. Learn from the problems and try again, and only take new technologies to the public when the confidence level is high. I hate to see the “Johnny-come-lately’s” who did not help grow this business early, come in and ruin the market just when it is starting to grow.
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Brian

3.5.6.2 Vibratory Screed Construction. Pervious concrete is manually compacted at the edges during placement, prior to screed operation. The vibratory screed is supported by edge forms and ½ inch riser strips to elevate the screed ½ inch above finished elevation. The vibratory truss screed is drawn over the slab at low intensity vibration with precaution to stop vibration if travel movement is stopped. Riser strips are removed after screed operation is complete and a full width static roller is deployed on the slab surface to compress the pervious concrete down to finished elevation.
3.5.7 Magnesium hand floats, steel trowels and steel edgers will be used to complete compaction and finish pavement surfaces.
3.5.8 The pervious concrete pavement shall be compacted to the required cross-section and shall not deviate more than +/- 3/8 inch in 10 feet from profile grade.

3.7.1 Static Roller A minimum 10 inch diameter steel cylinder that spans the width of the section placed and exerts a vertical pressure of at least 40 pounds per lineal foot on the concrete surface. The static roller is rolled over the slab surface after riser strips are removed from the formwork to compact the surface.

3.7.1
Surface Compression
Compression and consolidation must be considered separately. As consolidation occurs at the point of delivery, compression is applied later, with mechanical pressure applied to the surface.

3.7.1 Cross Roller A rolling cylinder deployed on the slab surface with extension handles to apply mild compression to the surface.
3.9 Tolerance, compaction, elevation, thickness, joint depth.

Pervious concrete pavement is designed with specific void content which results in reduced density and reduced strength. This is the result of the hydrological features that are built into the pavement. The structural limit of this concrete is compensated by enhanced thickness of the pavement section. Structural performance is enhanced by thicker aggregate base materials and a thicker concrete slab.
Historically, structural designers were encouraged to substitute conventional concrete in areas where heavy loads are routine. This is safe advise but pervious concrete pavement has shown good structural performance in heavy loads if pavement thickness is 10 inches or more.
The strength of pervious concrete becomes subject to many potential threats during installation. All of these can affect the strength of the finished product and the ability of the pavement to sustain the design load. Our objectives include enhanced thickness as well as uniform thickness, during the course of construction. As base materials are placed and graded, uniform thickness is established and maintained through all incidence of construction traffic.

3.11.3 Fogger A fog emission device used to deliver water mist in the air passing over nozzles used to replenish water lost through evaporation from the slab surface. Fog emission is required for Pervious Concrete placement in low humidity and windy conditions.
3.12.2.1 Jointing plastic concrete shall be performed utilizing a jointing cross roller of sufficient depth and a uniform radius formed at both sides of the flange of the jointing cross roller. Joints are tooled immediately after compaction is complete.
3.12.2.1 Cold joints and shrinkage
One of the great aspects of pervious is in the aggregate contact. Pervious aggregate is touching other aggregate in at least five or six places, where load transfer occurs. The best pervious mix proportion uses a paste that deforms and allows the aggregate to touch. Then the paste reforms into the paste bridge that surrounds the contact point.
Shrinkage is mostly attributable to the frailties of the paste. Since pervious aggregate is not separated by paste, shrinkage is very slight.
After explaining some reasons why you may not need expansion joint filler about the perimeter, install it anyway. Most builders find it sufficient to install the geo textile continuing up through the face of the joint. The typical aggregate used to fill the detention basin in pervious systems should be protected from soils migrating into the system by surrounding the detention basin with geo textile. This can be easily fastened to your curb.
Many do not joint pervious pavement but it should be jointed at twenty feet or square. All of these joints or a third of them should be tooled during the placement. The remaining joints may be saw cut after the risk of ravel has passed. The conventional advice is to avoid sealing control joints but I do it anyway. It seems the best way to prevent silt & contaminant from occluding the joint.

3.12.3.1 Jointing tool flange is a machined part with separate knife components assembled in a compression fit. None of the flange components are welded. We propose to use 3/8 radius at both sides of the flange to provide suitable compaction of pervious materials adjacent to the joint. We propose to tool control joints to divide the aggregate matrix to a depth of two inches and allow the bottom of the joint to close during cross rolling procedures that follow.

3.12.3.1 Jointing Cross Roller A rolling cylinder with a circular plate fin attached near the center. This is deployed on the slab surface with extension handles to divide the aggregate and form a control joint.

3.12.3.2 Early entry saws are not used in this process. Timing sequence, slow hydration rate and raveling issues prevent the use of early entry. Consider tooling every third transverse joint and saw the rest after the sheeting is removed. Vacuum the cuttings.

3.14 Maintenance

The service life of pervious concrete pavement is similar to that of conventional concrete pavement. If the concrete is produced and installed properly, with respect to the specified design, a thirty year service life can be expected. Successful design and construction will include provisions for maximizing cement hydration and load transfer within the concrete itself. As well, it includes adherence to design provisions for freezing climates.

Pervious concrete pavement is designed to limit the sources of contamination which may clog the permeability of the surface. This is usually done by designing surface elevations that are higher than adjacent sources of contamination. Separate structures or barriers may be used to block or slow the flow from surrounding areas which run storm water onto the slab surface.

3.14.3 de icing

question about mix proportion, relative to freeze/thaw

the raveled condition you are seeing is a heartbreaker but you have plenty of company. This condition is commonly seen in pervious with hydration problems. Usually it comes from limiting water content in the mix or a loss of water during installation or both. The key issue in balancing the proportions of a pervious mix design to allow enough room for the free and generous use of water during production and installation. This is the central issue of my crusade, for lighter and wetter pervious mixes and methods. You can contact me personally if you want help with this.

It’s true that the deicing did not help it but your main problem was created the day it was installed. The freeze just finished it off. I suggest remove and replace.