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The Sustainability of Concrete Pavements

Variation in Concrete Strength Due to Cement

The Seven Common Mistakes Made By Salespeople
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About a year ago, NRMCA rolled out the “Safety Alert” Web site. These are actual accidents and incidents involving ready mixed concrete companies. The company-specific data (company name, plant name, etc.) has been removed to help provide anonymity to the company. The point is that an accident has happened and by sharing these “Lessons Learned” another accident or incident can be averted.

Pictured on this page is an all too often image of a mixer involved in a rollover. The company involved took the photo and performed an accident investigation. The lessons learned were sent companywide along with a training outline to help stress the accident cause to other company personnel.

These “Safety Alerts” are great tools for training. The ready mixed concrete industry is pretty much the same throughout the country. If this accident happened at one plant, or on the road in this case, it can happen at others.

NRMCA is soliciting producers to send their safety alerts to dayers@nrmca.org. Your company-specific data will be removed to keep your anonymity. The safety alert will only be published after your final approval that all company-sensitive information has been removed. This is a good way to help others and your other plants from having the same kind of accident or incident. For production and safety personnel, these can be covered immediately. The NRMCA Safety Alerts can be accessed at: http://www.nrmca.org/operations/SAFETY/Safety_Alert.htm

When a new “Safety Alert” has been placed on NRMCA’s Web site, an e-mail will be sent to the NRMCA Safety Task group. Anyone can join the NRMCA Safety Task Group and we look forward to more participation from more companies.
Variation in Concrete Strength Due to Cement
Part III of Concrete Quality Series

By Karthik Obla, Ph.D., P.E., Vice President, Technical Services, NRMCA

Parts I and II of the Concrete Quality series 1,2 discussed that to attain good concrete quality a concrete producer needs to target a low standard deviation of compressive strength. In order to reduce the strength standard deviation, the material, manufacturing and testing variations need to be lowered. This article discusses concrete strength variability due to variation of cement from a single source.

Cement from a given source varies between shipments

It is well understood that there are significant differences in strengths of Type I cements from different sources. How variable is the strength of different cement shipments from the same source? One of the most exhaustive studies to address this question was conducted by Walker and Bloem back in the 1950s at the NRMCA/NSGA Joint Research Laboratory3. Cement samples were secured from each of 5 sources every 2 weeks from October 1955 to October 1956 and stored in sealed containers. A sixth cement consisting of a blend of 5 cement brands from the Washington area was thoroughly mixed at the start of the program and stored in sealed containers for use as a control. Three principal series of tests were conducted at different times. The first series involved standard mortar strength tests (ASTM C109) on all samples; the second, concrete tests on selected samples; and the third, concrete and mortar tests on selected samples.

In the first series five mortar batches were made on different days with each cement sample including the control; each round including all sources was made on the same day. All work was performed by the same operator. Nine cubes were molded from each batch for strength tests in triplicate at 3, 7 and 28 days age. The series involved testing of approximately 7000 2-in. mortar cubes.

In the second series concrete batches with a cement factor of 517 lb/yd³ and mixed to a constant slump of 3 to 5 in. were made using samples of cement which had produced the highest, median and lowest mortar strengths from each of the 5 cement sources in Series 1. Concrete cylinders of size 4x8 in. were tested in triplicate at 3, 7 and 28 days. Due to the space restrictions only series 1 and 2 are discussed below. Series 3 findings were in line with Series 1 and 2.

Figure 1 shows the percentage distribution of mortar strengths about the average for all 3 test ages. The percentage strengths at each age have been arranged in order of descending magnitude. If the different shipments from the same source were absolutely identical and the cement was essentially uniform, one should observe a perfectly horizontal line at 100%. Source 1 (control) approaches that and the small variability is primarily due to variation attributed to testing. All the cement sources showed a greater variation than the control with some of them better than the others.

Table 1 summarizes some of the statistical data of the 28-day mortar strength test results of the 5 sources. On the basis of sample-to-sample variation, the source with the lowest sample-to-sample standard deviation is the best, followed by the lowest batch-to-batch standard deviation.

Table 1. Statistical Summary of 28-day Compressive Strength Tests of Mortar3

<table>
<thead>
<tr>
<th>Source</th>
<th>Control (Source 1)</th>
<th>Source 2</th>
<th>Source 3</th>
<th>Source 4</th>
<th>Source 5</th>
<th>Source 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average, psi</td>
<td>5198</td>
<td>5355</td>
<td>4950</td>
<td>3674</td>
<td>5434</td>
<td>4582</td>
</tr>
<tr>
<td>s₁, psi</td>
<td>133</td>
<td>132</td>
<td>125</td>
<td>79</td>
<td>137</td>
<td>111</td>
</tr>
<tr>
<td>s₂, psi</td>
<td>119</td>
<td>131</td>
<td>127</td>
<td>81</td>
<td>137</td>
<td>114</td>
</tr>
<tr>
<td>s₃, psi</td>
<td>123</td>
<td>339</td>
<td>362</td>
<td>244</td>
<td>520</td>
<td>245</td>
</tr>
<tr>
<td>n₁, %</td>
<td>2.6</td>
<td>2.5</td>
<td>2.5</td>
<td>2.1</td>
<td>2.5</td>
<td>2.4</td>
</tr>
<tr>
<td>n₂, %</td>
<td>2.3</td>
<td>2.4</td>
<td>2.6</td>
<td>2.2</td>
<td>2.6</td>
<td>2.5</td>
</tr>
<tr>
<td>n₃, %</td>
<td>2.4</td>
<td>6.3</td>
<td>7.3</td>
<td>7.3</td>
<td>9.6</td>
<td>5.3</td>
</tr>
</tbody>
</table>
Coefficients of Variation (COV) over the duration of the shipments all five cement sources showed considerably greater variability than the control, as should be expected. These COVs ranged from 5.3 to 9.6% as compared with only 2.4% for the control—the COVs for the various sources was even higher with early age strengths. The average 28-day sample-to-sample standard deviation for the 5 sources of cement was 342 psi. ACI 214R-02 states that a good standard of concrete control for general construction testing is a standard deviation of 500 to 600 psi. Even though the cement strength standard deviation may not translate directly to a concrete strength deviation of the same magnitude, cement variation plays an important role in concrete strength variability and it should be clear that variation in strength producing property of cement from a single source cannot be ignored.

Figure 2 shows that C109 mortar strengths correlate very well with concrete strengths from the Series 2 work for all sources. This confirms that for a given source, variation in cement strengths between shipments causes variations in concrete strengths. For the 28-day tests the average strengths of the five sources ranged from a high of 4880 to a low of 4060 psi, an overall spread of 820 psi. This variability in concrete strengths will necessitate an increase in cement content to achieve a higher target strength to accommodate this variability. Contrary to this Weaver et al. reported that for the same cement source as shipments changed there was no correlation between the C109 mortar strengths and corresponding concrete strengths. Gaynor conducted an exhaustive study of past NRMCA research. He states that variations associated with testing of C109 mortar strength, as well as with concrete strength, are not insignificant. When the cement is very uniform and real cement strength variations are small, the testing variation is large enough to mask the variability that can be attributed to variation of the cement source. Additionally, when only single batches of mortar or concrete are tested correlation between these strengths are not obvious because of testing variability. However good correlations were obtained if several batches of mortar and concrete are prepared from the same sample or enough consecutive samples (5 or 10) are averaged. Gaynor concluded that there was indeed an excellent correlation between

Figure 1. Percentage Distribution of Mortar Strengths about Average

Figure 2. Relationship Between Compressive Strength of Constant-Slump Concrete and C109 Mortar for Control and the 5 Cement Sources

Figure 3. Running 5 Test Average of C109 Mortar Cubes (C917 Report) Vs Running 5 test Average of Concrete Cylinders Tested at 28 days
and led in 1980 to the development of ASTM C917 for Standard Test
silicate (C\textsubscript{3}S) content was a primary factor that can be attributed
significantly. The authors concluded that variation in the tri calcium
compressive strengths was noted for sources 2-5. For source 6 such
a correlation was not observed but the fineness was found to vary
significantly. The authors concluded that variation in the tri calcium
silicate (C\textsubscript{3}S) content was a primary factor that can be attributed
to variability in mortar strengths between shipments from a given
source. The authors did not notice any correlation between cement
strength performance and the changing seasons.

A 1962 study\textsuperscript{6} by the same researchers looked at 14 cements
sources with 2 different operators and came to similar conclusions
as the earlier study. In 1977 over 100 cement plants in the U.S. and
Canada participated in a year-long grab sample testing program.

Cement companies collected 10 grab samples every month from ship-
ment containers. Grab samples better represent the cement received
by the concrete producer. The data from the 1977 study was statistical
evaluated\textsuperscript{8,9} by a joint NRMCA/PCA Technical Liaison Committee
and led in 1980 to the development of ASTM C917\textsuperscript{10}, Standard Test
Method for Evaluation of Cement Strength Uniformity from a Single
Source. In a later article Gaynor\textsuperscript{11} analyzed the data and reported the
variation in the monthly moving average strength (10 sample moving
average) during the course of the year. This is reproduced in Table
2. A typical overdesign for concrete furnished under the ACI 318
Building Code is about 20%. Table 2 shows that about 40% of the
cement plants experienced changes in strengths exceeding 15%. Half
of these plants had an increase in strength. This again confirms that
that variation in strength producing property of cement from a single
source cannot be ignored.

Table 2. Changes in Cement Plant Monthly Moving
Averages of Mortar Strengths\textsuperscript{11}

<table>
<thead>
<tr>
<th>Percent Change in 10 samples 28-day strength, %</th>
<th>% of plants exceeding</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>97.1</td>
</tr>
<tr>
<td>10</td>
<td>86.4</td>
</tr>
<tr>
<td>15</td>
<td>38.8</td>
</tr>
<tr>
<td>20</td>
<td>17.5</td>
</tr>
<tr>
<td>25</td>
<td>4.9</td>
</tr>
<tr>
<td>30</td>
<td>1.0</td>
</tr>
</tbody>
</table>

ASTM C917

ASTM C917 is the standard test method for Evaluation of
Cement Strength Uniformity from a Single Source. C917 is typi-
cally done on the predominant cement sold at a cement plant. Grab
samples of cement are taken from normal delivery units, either
to cement strength variation is a first step in understanding the causes
of the overall concrete strength variation. Such an understanding can
help find ways to lower the concrete variability, reduce cement factors
in concrete and attain improved quality.

C917 – How Should a Ready Mixed Concrete
Producer Use it?

Cement Choice

Cement strength uniformity (ASTM C917 test data) can be con-
sidered in cement purchase decisions by the ready mixed concrete
producer. Apart from ASTM C150 mill test reports concrete pro-
ducers should request to see ASTM C917 test reports over the past
12 months. Everything else being equal, a cement that has a lower
standard deviation as measured by ASTM C917 will be more uni-
form and will generally result in a lower concrete strength standard
deviation. This can result in a lower target average strength and a
lower cementitious content for a given strength level.

Better Understand Concrete Variability and lower it

ASTM C917 test data can be used to lower overall concrete vari-
ability and hence improve quality. If periodically (once a week) stan-
dard concrete mixtures (the most commonly sold mix at that plant for
example) are cast and strength properties evaluated it becomes possi-
ble to correlate the cement strength variation to concrete strength
variation. Figure 3 shows how a concrete producer\textsuperscript{7} tracked the five-
test running average of C109 mortar cube strengths from the C917
test report. Superimposed is a five-test running average of concrete
cylinders test results made from a standard 450 lb/yd\textsuperscript{3} cement factor,
3000 psi concrete mixture. Both the mortar and concrete strength
curves show a downward trend from mid March to mid June followed
by a sharp increase. A typical 2- to 5-day time lag for rail shipments
to the ready mix plant would explain some of the apparent shift in
peaks. A good understanding of the concrete strength variation due
to cement strength variation is a first step in understanding the causes
of the overall concrete strength variation. Such an understanding can
help find ways to lower the concrete variability, reduce cement factors
in concrete and attain improved quality.
Reduce Low Breaks and Optimize Mixture Proportions

This is perhaps the most important use of ASTM C917 test data and it can help the producer lower costs. If a process variable in cement manufacturing has changed and the cement strength is trending upward timely communication from the cement manufacturer can help the concrete producer optimize concrete mixture proportions. On the other hand if the cement strengths are trending downward mixture proportions may have to be changed to prevent low strength test results. To be effective, communication should occur as soon as 7-day mortar test results are available or even earlier if process changes have occurred at the cement plant that are known from experience to change the strength producing property of cement in a certain manner. In periods of high volume use, it is also possible that cement producers might switch the cement source shipped to the concrete producer.

It is important not to be alarmed by a single low or high cement 7- or 28-day strength test result. 7-day test results are preferable as they provide a quicker opportunity to make changes as needed. A single low strength could be because of testing or genuine material variation. However if there is a pattern of low strength results then it suggests a “change point” has occurred; the average strength has reduced; and that reduction in cement strength has to be managed by changing the concrete mixture proportions to avoid low concrete strengths. The change point could be due to a testing bias but that is generally unusual and the cement manufacturer can rapidly investigate that. Most likely the change point is due to a genuine change in the strength producing property of the cement itself. Control charts of running averages of 3 or 5 consecutive test results and Cusum charts can help understand if change points have occurred. The concrete producer can choose to adjust mixture proportions if certain control charts limits are exceeded. If running average of 5 consecutive test results are plotted on a control chart, statistically there is only a 2% chance that test results will fall outside limits set at 1.042 x Vt percent from the average; where Vt is the total coefficient of variation of the cement strength. Vt is calculated in percent as the ratio of the standard deviation (St) and average strength (X) reported in a C917 test report.

Example: For X = 4000 psi, St = 240 psi, Vt can be calculated as 6%. Limits for the 2% chance can be calculated as 6.25% from X which gives an upper control limit of 4250 psi and a lower control limit of 3750 psi.

Troubleshoot Low Strength Problems

When C917 data is available, concrete producers can also use it to troubleshoot low concrete strengths in evaluating whether the cause for the low cement strength can be attributed to a reduction of the cement strength. Other factors, such as mixing water, air content, batching errors, testing errors etc., should also be considered. Concrete producers should also keep 5-lb samples of cement from each shipment in sealed containers so that these can be tested if necessary. It is advisable to retain cement samples for 3 to 6 months from the date the shipment was received.

C917 – How Should a Cement Producer Use it?

Concrete manufacturing is an intensive process of using naturally available (variable) resources and manufacturing process variables. The cement manufacturer clearly has a goal of minimizing variability and has access to various tools and methods to monitor cement variation. A large cement producer can look at the annual COVs measured according to C917 at various cement plants and try to better understand the reasons for lower variability at certain plants and duplicate them elsewhere. Sometimes the higher COV attained at a plant is because of a wider variability in the raw materials of the cement itself. This was referred to by a cement producer discussing the 1958 research study. He says that some plants had a wider variation of silica content in their raw materials. If those plants attempted to control their composition of raw mixes by just the analysis for the carbonate portion they could end up with wide variations in tri-calcium silicate contents. The cement producer can target a lower COV as measured by ASTM C917 by identifying the key strength producing characteristics, such as tri-calcium silicate content, fineness, gypsum content, etc. and attempt to control them. It has been suggested that ASTM C150 itself should have limits on the extent to which some of these properties can vary. In 1975 Bryant Mather then president of ASTM discussed the lower-limit-only cement strength specifications: “We need to do something about the variability. We need to put into the ASTM standards some way by which the user can require not just compliance with the minimum, but an assurance of some degree of uniformity”. An attempt at this was to incorporate a cement strength range concept in ASTM C1157, but it was dropped because of significant confusion on how cement could be ordered.

As discussed in the previous section as soon as the 7-day running average of 5 consecutive C917 strength test results fall outside previously agreed upon control limits the cement producer could communicate that to the concrete producer so that suitable actions can be taken. Communication can even be earlier if process changes have occurred at the cement plant that are known from experience to change the strength producing property of cement in a certain manner. Timely communication can reduce low strength problems in the field and the accompanying investigating costs.

It is important that the concrete producer and the cement manufacturer work as a team as it is in the best interests of both that concrete of good quality with low variability and reduced low strength problems are made and placed. A good understanding of cement strength variations through effective use of ASTM C917 is essential in this regard.

References

2. Obla, K.H., “Sources of Concrete Strength Variation – Part II of Concrete Quality Series,” Concrete InFocus, July-August 2010, Vol. 9, No. 4, NRMCA, pp. 21-23.
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Kuhlman Corp.

Ohio Ready Mix Producer Holds Art Exhibit Highlighting Concrete’s Versatility

By Frank Cavaliere, Director of Communications, NRMCA

For more than 100 years, customers have been walking into the Toledo, OH, area headquarters of Kuhlman Corporation, but until this summer very few began their visits astonished. Until earlier this year, no one at the venerable Northwest Ohio building products company had thought to feature the myriad ways that concrete can be molded into an art exhibit. That changed in July when Kuhlman opened its headquarters in Maumee, a Toledo suburb, to Art de Concrete, the region’s first concrete art exhibit.

While concrete’s versatility as a building material has long been known and promoted within the industry and has been widely used by artists, exhibits conceived and operated by ready mix producers are almost nonexistent. They would have been even rarer had the wife of company President Tim Goligoski not convinced her husband to accompany her last December to a local arts and crafts sale. When one artist’s creation of concrete leaves caught their eye, “I told Tim that we ought to do a concrete art show since we have the ideal setting for it,” explained Sally Bartholomew Goligoski, a great-granddaughter of the company’s founder, Adam Kuhlman.

This seemingly offhand comment quickly veered toward “concrete” plans. “He said to go for it, but you don’t have a budget and you must go easy on using Kuhlman employees,” she said, adding that plans “snowballed” from there. A committee of local artists and other interested parties was quickly assembled, with “terrific” response from the local arts committee. Details were worked out, contracts signed and the opening set for July 16.
For more than 100 years, Kuhlman has supplied much of the ready mixed concrete, brick, sewer/water materials and concrete/masonry specialties used to construct Toledo and surrounding communities. Kuhlman continues to supply concrete and more than 5,000 different construction products to 4,000 customers – contractors, architects, engineers, plant and facility managers, and bulk shippers. In addition to Toledo, Kuhlman has concrete operations in Monroe and Adrian, MI and Ft. Myers, FL, plus a concrete and masonry products operation in Akron.

Company founder Adam R. Kuhlman, the son of a German immigrant, was a bricklayer and mason contractor. In the late 1890s, he and Richard Kind formed the Kuhlman-Kind Co., which sold building materials. In 1901, the new firm merged with three other companies to become Toledo Builders Supply, predecessor of today's Kuhlman Corporation. Adam Kuhlman was named vice president of the Toledo Builders Supply and in 1916 became its president. In the mid-1920s, Adam Kuhlman formed the Kuhlman Builders Supply and Brick Co., which bought out Toledo Builders Supply in 1928. In 1928, the company became the first in Northwest Ohio and one of the first in Ohio to enter the ready mixed concrete business. Its first mixer had a two-cubic yard capacity and cost $3,000. After Adam Kuhlman’s death in 1933, the company was passed on to his sons, Charles and Edwin.

Charles Kuhlman died suddenly in 1956 and long-term employee Clyde Stevenson was elected president. The company then made several ready mix acquisitions, including Koder Concrete and Supply, Inc.; Carl Zenz and Associates Co. and Knapp Ready Mix, Inc., which extended Kuhlman’s concrete operations into Southeastern Michigan. The purchase of Wood County Transit Mix added Bowling Green to Kuhlman’s territory. Upon Stevenson’s death in 1967, Marion S. (Bart) Bartholomew, Charles Kuhlman’s son-in-law, took over the firm’s helm.

The fourth generation to head Kuhlman began in 1987 when Bartholomew’s son-in-law, Tim Goligoski, assumed the presidency of the company. Now, during peak times, Kuhlman operates about 50 mixer trucks in its ready mix operations along with six plants that serve Northwest Ohio, Southeast Michigan and the Fort Myers area of Florida. The Ohio and Michigan economic climate is “still very challenging, with a glimmer of getting better,” Tim Goligoski said.

He added that he believes Kuhlman and other construction-related firms are still one to two years from a measurable recovery. In the meantime, he said the majority of Kuhlman’s ready mix business is in area public works, such as schools and highways. The private sector, particularly residential housing and commercial work, is “very slow.”
Art de Concrete’s debut was an incredible success, attracting more than 500 on opening night. “We were flabbergasted by the response,” declared Ms. Goligoski. “The show features more than 30 works by nine artists, including one from the Toledo Museum of Art.” Fourteen large pieces are displayed outside, with the rest inside the Kuhlman Corp.’s showroom. Kuhlman’s quality control manager formed the concrete pads for most of the exterior sculptures.

As part of the exhibit, Kuhlman concrete specialists are leading a series of concrete workshops for local specialists and area college students, an idea Kuhlman hopes to expand next year. She added that “Kuhlman University,” the company’s 75-seat auditorium, and the Kuhlman yards are perfect venues for such workshops.

While her husband didn’t commit to holding another exhibit, he readily acknowledged the benefits of this year’s events, noting that more than two months after the opening, about a dozen people daily come to view the sculptures at the Kuhlman property. “It has allowed us to showcase a different aspect of concrete and cement,” Goligoski explained.

In addition to the sculptures, he acknowledged that Kuhlman benefits from the positive public relations generated by Art de Concrete. For an $8,000 investment for mailings, publicity, food, drink and other expenditures tied to the exhibit’s opening, Goligoski said that the public has been exposed to Kuhlman and, hopefully, will turn to the company for its building products needs once the recession ends in its service area.

“Right now, it’s particularly tough here in Ohio and Michigan,” he said. “At Kuhlman we’ve had to lay some people off, have a wage freeze and endured a 10-week Teamster strike this summer. Our mood could always use a good pick-up and Art de Concrete has helped with that.”
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Our economy depends on transportation infrastructure. We drive to work and school on roads each day. Most of our food, clothing and consumer products are delivered in trucks that travel our interstate highway system. Businesses rely on roads and runways to transport materials and parts needed to manufacture the products we use every day. Families rely on these same roads and runways to visit friends and family or to take vacations. And when we reach our destinations, we rely on driveways and parking areas to park our cars and trucks. We even rely on sidewalks to get us where we’re going.

Our transportation infrastructure connects our communities. Without it, we would not be a productive society. However, this interconnecting network of roads, runways, parking areas and sidewalks does have an impact on our environment. The same cars, trucks and airplanes that support our economy also use energy, emit greenhouse gases and other air emissions, and can place a significant toll on surrounding ecosystems. The construction process, including material manufacturing, can also burden on the environment. Therefore, when we build new transportation infrastructure or repair and maintain existing infrastructure, it makes sense to use design strategies that minimize environmental impact.

What Makes a Pavement Sustainable?

Pavements should have a long service life and require little maintenance. They should minimize energy consumption and greenhouse gas emissions. They should be resource efficient by using local materials and incorporating recycled materials. One way to accomplish these objectives is to use concrete pavements. Concrete pavements can be used to build new or replace existing sidewalks, driveways, parking lots, local streets and roads, highways and runways. Concrete pavements can be designed economically to carry light loading such as pedestrians and passenger vehicles all the way up to the heaviest trucks and airplanes. Concrete can also be used to repair deteriorated asphalt pavement with a product called whitetopping or concrete overlay. Other products such as pervious concrete, that allows rainwater to pass through it, can help reduce and treat stormwater.

When evaluating environmental impacts, it is important to look at the entire life cycle of a product or project. Looking at one phase of the life cycle, such as material extraction, manufacturing or construction, and ignoring the operation or use phase may not result in the most efficient design. This paper explores how concrete pavements can improve our transportation infrastructure and minimize environmental impacts throughout all phases of a pavement’s project life cycle, including material extraction, manufacturing, construction, use (operations and maintenance) and recycling.

Durability

Excessive wear and tear on vehicles is directly related to the quality of roads. According to the Federal Highway Administration, the percentage of roads classified as having “acceptable” ride quality has steadily declined over a 10-year period from 1995 to 2004 from approximately 87% to 85%. The lowest acceptable ride quality was found to be approximately 72% in some urban areas. Congestion continues to increase and clog America’s roadways, costing taxpayers millions of dollars and billions of wasted hours. On average,
Americans spend more than 4 billion hours a year stuck in traffic, costing 78.2 billion dollars per year in wasted time and fuel. This accounts to over $700 per American motorist. The problem continues to rise and congestion has increased 26% in 1995 to 32% in 2004. The resulting wasted fuel increased (4.54 billion) liters 1.2 billion gallons in the 10-year period.  

Providing durable, long lasting roadways that require little maintenance can reduce the wear on our cars and trucks and decrease the congestion on our roadways. Concrete pavements are durable and as a result they generally have longer service lives than asphalt pavements. There are many examples of concrete pavements with service lives of 50 years or longer. Concrete pavements do not require rehabilitation or reconstruction as often as asphalt pavements and as a result the life cycle cost of concrete pavements are lower and losses in productivity as a result of lane closers are reduced.

### Lower Embodied Energy

The embodied energy of a material refers to the energy needed to extract, process and refine it for its intended use. Thus, a correlation exists between the number and type of processing steps and the embodied energy of a material. For example, the fewer and simpler the extraction, processing and refining steps involved in a material’s production, the lower its embodied energy. The embodied energy of a pavement is the total energy required to extract materials from the ground, process these materials, produce the pavement, construct the pavement, provide maintenance over the specified time period, and recycle or demolish the roadway at the end of its specified life.

The Athena Institute studied the embodied energy and global warming potential over a 50-year life cycle. The study concluded that for a high volume highway, the asphalt pavement alternative required three times more energy than its concrete pavement counterparts from a life cycle perspective. For a high volume roadway, asphalt generated global warming potential of 738 t/km (1309 tons/mi) of CO₂ equivalents compared to 674 t/km (1196 tons/mi) of CO₂ equivalent for concrete. The study did not take into account addition fuel savings or energy savings from lighting as described later in this paper that would further reduce the embodied energy and CO₂ equivalents associated with concrete pavements.

### Fuel Savings

Several research studies have shown that driving on concrete pavements uses less fuel and as a result, lowers carbon emissions and other associated emissions when compared to asphalt pavements. Although the reasons are not completely understood, the theory is that because concrete pavements are considerably stiffer than asphalt pavements they deflect less when subjected to vehicle loading. This means that a car or truck traveling on a more flexible pavement absorbs part of the vehicle energy that would otherwise be available to propel the vehicle, thus requiring more fuel.

The studies have shown that trucks demonstrate fuel savings when driven on concrete highway pavements versus asphalt highway pavements. Fuel consumption for cars are not influenced by pavement type for highways presumably because they are lighter in weight and the deflections are such that they do not affect fuel consumption significantly. However, one study shows that cars traveling on city streets do demonstrate lower fuel consumption on concrete pavements compared to asphalt pavements. It is assumed that because the pavement cross sections are thinner for concrete streets that deflections caused by passenger vehicles are large enough that they do affect fuel consumption.

Zaniewski conducted one of the earliest fuel consumption studies commissioned by the Federal Highway Administration (FHWA) in 1982. He conducted one of the earliest fuel consumption studies commissioned by the Federal Highway Administration (FHWA) in 1982. In this study, fuel consumption data was collected for different vehicle types, pavement designs, pavement conditions, and pavement grades and curvatures. Twelve highway sections were tested, some concrete and some asphalt. Vehicles were driven at different speeds ranging from 16 to 112 km/h (10 to 70 mph) and fuel consumption was accurately measured while other variables, including pavement roughness, remained constant.

The test results indicate that fuel consumption for trucks, ranging from 2-axle pickup trucks to 4-axle semi-trailer trucks at speeds greater than 32 km/h (20 mph), was lower for concrete highway pavements then for asphalt highway pavements. The difference in fuel consumption was as much as 0.85 km/l (2 mpg.) The semi-trailer truck in this study had fuel consumption of approximately 1.91 km/l (4.5 mpg) on the asphalt pavement and 2.33 km/l (5.5 mpg) on the concrete pavement, meaning the average savings was approximately 20% for semi-trailer trucks.

Another comprehensive study of fuel consumption was conducted by the National Research Council of Canada with reports published in 2002 and 2006. Semi-trailer trucks were driven on highway pavements in Ontario and Quebec comparing fuel consumption for asphalt and concrete pavements. Variables studied in the analysis included pavement roughness, load, speed, season, temperature, grade, and wind. Onboard state-of-the-art real time computerized data collection equipment was used in the tractor trailer unit to collect and calculate instantaneous fuel flow while traveling over the different pavements.
The semi-trailer data was analyzed using a multivariate linear regression analysis tool to determine the potential savings and the statistical significance of the results. The results of the 2002 study showed statistically significant fuel savings for trucks operating on concrete pavements over asphalt pavement ranging from:

- 4.1% to 4.9% savings on concrete pavement at 100 km/h (62 mph)
- 5.4% to 6.9% savings on concrete pavement at 60 km/h (37 mph)

The results of the 2006 study shows statistically significant fuel savings for trucks traveling on concrete pavements over asphalt pavements ranging from:

- 0.8% to 1.8% savings on concrete pavement at 100 km/h (62 mph)
- 1.3% to 3.9% savings on concrete pavement at 60 km/h (37 mph)

Based on these studies, Table 1 shows the annual potential fuel savings, cost savings and reduction in CO$_2$, NO$_x$, SO$_2$ if a tractor trailer operated a total of 160,000 km/year (99,419 mi/year). It is assumed the semi-trailer truck has a fuel consumption of 2.33 km/l (5.47 g/mi) and an average cost of diesel fuel of $0.80 per liter ($3.02 per gallon).

The University of Texas at Arlington investigated the differences that might exist in fuel consumption and CO$_2$ emissions when operating an automobile on asphalt street pavements versus concrete street pavements under city driving conditions. Two pairs of street sections, one asphalt and one concrete, with similar gradients and roughness were selected for fuel consumption comparisons.

The study concludes that driving on concrete pavements reduced fuel consumption by 3% to 17%, resulting in significant cost savings, fuel savings and reduction in CO$_2$ emissions. For example, if the annual vehicle miles travelled in the Dallas-Fort Worth region in Texas took place at a constant speed of 50 km/h (30 mph) on concrete pavements similar to those in the study, the annual fuel savings would be 670 million liters (177 million gallons) and the annual CO$_2$ reduction would be 620,000 tonnes (680,000 tons).

### Reduced Lighting Requirements

Darkness increases the potential for accidents. The fatality rate is approximately three times greater during the nighttime than during the daytime, when adjusted for vehicle traffic volumes. Therefore, in busy traffic areas, it makes sense to add artificial lighting to reduce accidents. However, lighting is expensive to install, maintain and operate. In a 1986 paper by Stark, the initial cost of purchasing and installing light fixtures for a typical roadway can range from $54,370 to $96,313 per kilometer ($87,500 to $155,000 per mile.) This is based on an estimated cost per light fixture of approximately $4,000. The Stark report also estimates the cost to operated roadway lighting to range between $1,367 and $2,485 per kilometer ($2,200 and $4,000 per mile) per year for energy and between $1,616 and $2,858 per kilometer ($2,600 and $4,600 per mile) per year for maintenance. All dollar figures have been adjusted for inflation.

Concrete pavements can reduce the initial costs, maintenance costs and energy demand for lighting since concrete is more reflective than darker pavements. Fewer lighting fixtures or lower wattage fixtures are needed to provide the same illumination on a roadway built with

<table>
<thead>
<tr>
<th>% Fuel Savings</th>
<th>Fuel Saved (l)</th>
<th>Fuel Savings ($)</th>
<th>CO$_2$ Equivalents (tonnes)</th>
<th>NO$_x$ (kg)</th>
<th>SO$_2$ (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.8 minimum</td>
<td>550.4</td>
<td>$440.32</td>
<td>1.51</td>
<td>17.18</td>
<td>2.17</td>
</tr>
<tr>
<td>3.85 average</td>
<td>2,648.8</td>
<td>$2119.04</td>
<td>7.31</td>
<td>82.68</td>
<td>10.45</td>
</tr>
<tr>
<td>6.9 maximum</td>
<td>4,747.2</td>
<td>$3797.76</td>
<td>13.09</td>
<td>148.18</td>
<td>18.73</td>
</tr>
</tbody>
</table>

**Table 1. Fuel and cost savings and emission reduction from driving trucks on concrete highway pavements versus asphalt highway pavements.**

---

![Figure 2. Reflectance of concrete pavements (left) are higher than asphalt pavements (right), resulting in safer pavements and reduced energy consumption.](image)
Reduced Urban Heat Islands

Research at Lawrence Berkeley National Laboratory shows that the consistent use of light-colored pavements along with strategic landscaping and light colored roofing, can help reduce urban heat islands. An urban heat island is a metropolitan area which is significantly warmer than its surrounding rural area because of roofs and pavements that are baked by the sun and warm air. In many large cities, temperatures in residential zones can rise by as much as 1.7 °C (3 °F) and in downtown areas by as much as 3.9 °C (7 °F), primarily because of dark-colored roofing and pavements. The increased temperatures can cause discomfort, hike air-conditioning bills and accelerate the formation of smog. Cities such as Los Angeles, Chicago, Washington and Atlanta, along with many other U.S. cities are subject to the urban heat island effect.

According to the research, the use of light- and heat-reflective materials, along with careful planting of trees, could lower the average summer afternoon temperature in some cities by as much as 2.8 °C (5 °F), cutting the need for air conditioning by 18%. Since air-conditioners use electricity, primarily generated from coal-fired electric power plants, reducing urban heat islands can reduce energy consumption and related greenhouse gas emissions considerably.

Using light colored roofing and pavements can also benefit cities in the north. For example, in New York City, the length of the day in December is half that of a day in June. Also, the sun is so low in the sky that it shines on only half the roof or pavement area in December versus June. In addition, New York experiences three times more cloudy days in the winter than in the summer. When you multiply these three factors (1/2 x 1/2 x 1/3 = 1/12) the potential for horizontal surfaces to absorb the sun’s energy is only 1/12 in December as in June. This means that because so little sun ever reaches roofs and pavements in the winter months, the benefits of lowering temperatures in the summer far outweighs raising temperatures in the winter.

Stormwater Management

Pervious concrete is a performance-engineered concrete with a 15-30% void system that allows rainwater to percolate through it. When pervious concrete is used for parking areas, streets, plazas and walkways it minimizes stormwater runoff to surrounding streams and lakes and allows for natural filtration to recharge local groundwater supplies. Pervious pavement is especially compelling as a leading edge green building technology and is recognized by the U.S. Environmental Protection Agency (EPA) as a recommended Best Management Practice (BMP) for stormwater management that supports the principles of Low Impact Development (LID). Pervious concrete has been documented as eliminating stormwater runoff and improving potential water quality.

In addition to the stormwater management benefits of pervious concrete, it can also act to reduce the heat island effect of concrete by absorbing less heat from solar radiation than darker pavements. The relatively open pore structure and the light color of pervious concrete stores less heat, therefore, helping to lower heat island effects in urban areas. Studies by Hasselback and Keven have shown that pervious concrete stores less energy, therefore less heat, when exposed to sun over an extended period of time. This heat is not reflected back to the environment resulting in lower external temperatures. Lower external temperatures of the pavement result in a reduction of the heat island effect.

Recycling and Reuse

Concrete uses recycled materials in several different ways. The most widely used recycled products in concrete are Supplementary Cementitious Materials (SCMs) such as fly ash, slag cement and silica fume. In 2007, the concrete industry consumed over 26 million tonnes (28.66 million tons) of these industrial byproducts that would otherwise have end up in landfills. SCMs are the key to high performance concrete. When combined with cement in concrete they improve durability, strength and constructability. In the case of highways, streets and parking areas, durability is the number one concern. Fly ash, slag and silica fume are used to enhance durability by decreasing permeability and cracking. They help block migration of chloride ions to reinforcing steel, the most common cause of corrosion.

The environmental benefits of using these industrial byproducts in concrete means a reduction in the amount of waste materials sent to landfills, reduced raw materials extracted, reduced energy of production and reduced emissions including CO₂. Fly ash is the byproduct of burning coal in electric power plants. Generally, 15% to 20% of burned coal takes the form of fly ash. At one time, most fly ash was landfilled, but today a significant portion is used in concrete. Blast furnace slag is the byproduct of steel manufacturing. After grinding, the blast furnace slag takes on much higher value as a cementitious material for concrete. Blast furnace slag can be used as a partial replacement for cement to impart added strength and durability to concrete. Silica fume is a byproduct of processing quartz into silicon metals in an electric arc furnace. They are superfine, spherical particles that when combined with cement significantly increases strength and durability of concrete. It is used heavily for bridge and parking decks to produce concretes that are extremely durable.

The greatest opportunity for recycling lies in crushing concrete for various applications after demolition. After decades, or sometimes centuries, of use in a building or pavement, concrete can be crushed and reused. The Construction Materials Recycling Association estimates that 127 million tonnes (140 million tons) of concrete are recycled annually. Recycling concrete from demolition can be used for aggregate base for new pavements and some crushed concrete can be recycled as aggregate into new concrete. Recycling old concrete as aggregate protects natural resources by reducing the demand for virgin aggregate materials and eliminates the need to dispose of it into landfills. The same basic equipment used to process virgin aggregates is
used to crush, size, clean and stockpile recycled concrete aggregates. Ideal uses include fills and bases, roadways and parking areas, driveways and sidewalks, shoulders, curbs and gutters, landscaping features, foundations and some concrete structures including pavements.

According to a Federal Highway Administration study, 38 states recycle concrete as aggregate base and 11 recycle it into new concrete. In one example, recycled concrete aggregate was used for Interstate 5 improvements in Anaheim, CA. Crushed concrete from the demolition of the existing roadway was stockpiled for reuse as base material for the new roadway. The highway improvement project consumed all 635,029 tonnes (700,000 tons) of recycled concrete generated from the demolition and an additional 90,718 tonnes (100,000 tons) of recycled aggregate was brought in to complete the project. Using the recycled aggregate saved Caltrans approximately $5 million over purchasing and hauling virgin aggregate and disposing of the demolition debris.

Conclusions

Transportation infrastructure connects our communities and is a critical component to a vibrant economic system in the U.S. However, transportation is a large consumer of energy and emitter of greenhouse gases. One way to improve the overall environmental performance of our transportation infrastructure is to use concrete pavements since:

- Concrete pavements are durable and last longer
- Concrete pavements require less maintenance and fewer repairs
- Concrete pavements take less energy to build
- Cars and trucks traveling on concrete pavements consume less fuel
- Concrete pavements need less lighting
- Concrete’s light color helps reduce urban heat islands
- Concrete is made from local and abundant materials
- Concrete uses significant amount of recycled materials
- Concrete is recyclable

All of these features of concrete pavements help reduce energy consumption, greenhouse gas emissions and resource depletion attributed to our transportation infrastructure. For more information on the sustainability of concrete, visit www.nrmca.org/sustainability.

References

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Common Mistakes Made By Salespeople

By A. Vance Pool, Sr. National Resource Director, NRMCA

This is the first article in a series intended to aid in the initial training and upgrading of your sales force. Selling is a complicated process. By eliminating these common mistakes salespeople can become both more effective and more efficient, the two levers used to maximize your sales teams efforts. The common mistakes we will focus on are:

- Talking instead of listening
- Not having a process
- Not understanding the decision making process
- Allocating time improperly
- Selling what you want to sell, not what they want to buy
- Believing everything you hear
- Getting emotionally attached to the deal

Many sales managers became managers because they were good sales people and knew how to close the deal. As a sales manager it is easy to jump in and close the deal for your reps. While that may get a specific deal, it is much better to coach the sales team so that they can do the work themselves. Kind of like teaching them to catch their own fish. This series of articles is meant to help move that process forward.

The majority of salespeople like to talk. But talking can become preaching and it doesn’t necessarily address the needs of the customer. The best salespeople I know spend a long time listening before they say much. Think of it as the “gathering information” stage in the process. A good example of salespeople who don’t listen much are car salesmen. Over the years purchasing cars I have seen a lot of car salesmen who either don’t know their product or who immediately try to upsell me into a car that is either more expensive or that they have a lot of on the lot. Either way, it doesn’t make me want to buy their car.

Listening is one of the most important skills a sales person can have. Combined with asking the right questions it is crucial to move a deal forward. What kind of questions should we be asking?

- Is the project funded?
- Have the decisions that affect my product already been made?
- What is important to you?
- What are the three most important factors in your decision?
- Are there any others?
- Is that all of them?
- Who else is involved in the decision?
- Tell me more?
- Why is that?

The list of questions is endless. If you don’t know much, ask big open ended questions. If you need to know something specific, you can ask questions with yes or no answers to get to the real facts. Remember that too many yes/no questions will not have them talking much and could slow down your relationship building so make sure to use them strategically.

Why are we asking the questions? Because we want the client to talk and we want to listen. The best sales calls I have ever had are ones where I spent the vast majority of my time listening. I learn what the issues are, who the decision makers and influencers are as well as watch the body language of my client. If I know what they want it is much easier to build my pitch around their needs (assuming I can meet them). That speeds the selling process along as well as increases my chances of success.

It is so easy to present a canned pitch to a client. Many folks are trained to go out and sell that way initially. The odds of success on this approach are not nearly as good as when we listen. The more you listen the more you know. The more you know the better your chance of success.

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Several innovative concrete producers are currently earning financial incentives through the Cool Climate Concrete® (C3) program, a greenhouse gas offset program, by substituting supplementary cementitious materials for portland cement during concrete production. These producers receive incentive payments of $4 per metric ton of avoided carbon dioxide (CO2) emissions, a result of reducing their portland cement use beyond established baselines. Up to $800,000 in offset funding provided by The Climate Trust is currently available through September 2012.

PROGRAM BACKGROUND
The Climate Trust is a Portland, Oregon nonprofit, founded in 1997 to provide offsets to Oregon fossil-fueled power plants required to meet emission standards. They funded a first phase of the C3 program, which paid a total of $125,000 to participants for verifying 250,000 metric tons (mt) of avoided CO2 emissions, known as offsets under the program, resulting from their reduced portland cement use. After the first phase was successfully completed in September 2008, The Climate Trust committed an additional $1.25 million in offset funding to West Main Consultants, a sustainable materials consulting firm, to manage a second phase, which will verify an additional 200,000 mt of avoided CO2 emissions.

Ready mixed concrete manufacturers and concrete products manufacturers who purchase portland cement and supplemental cementitious materials (SCMs) from suppliers to blend their own cement during concrete mixing are eligible to participate. The program’s core
PARTICIPATION and offsets are generated. This emissions reduction strategy was developed since cement production represents the majority of emissions related to concrete; nearly one metric ton of CO2 is produced for every metric ton of portland cement produced.

While numerous SCMs are used in concrete production, only five have been approved as a portland cement substitute under the C3 program. These SCMs include ASTM C618 Fly Ash, ASTM C989 Grade 100 or 120 Ground Granulated Blast Furnace Slag (GGBFS), ASTM C1240 Silica Fume, Rice Hull Ash and Cement Kiln Dust, and were selected because they do not represent a net increase in emissions as they are byproducts of other processes (except in the case of GGBFS, where associated emissions are accounted for in program calculations).

OFFSET QUALITY

The program secures offset quality through a number of mechanisms detailed in a Monitoring and Verification (M&V) plan cooperatively developed by West Main Consultants and The Climate Trust. The plan clearly defines how offsets are generated, who owns the offsets, and the process and parties involved in offset quantification.

The M&V plan also addresses additionality, an issue central to all offset programs and crucial for establishing quality offsets. The additionality concept, necessitated by evolving offset practices, establishes that in order for a quality offset to exist, it must be created as a result of activities that go beyond business-as-usual. The C3 program considers industry-wide standards and participants’ historical portland cement use to determine business-as-usual practices, and employs a sliding historical use baseline, which is updated annually to incorporate the most recent year of participation. The sliding baseline requires participating companies to progressively reduce portland cement use in order to continue generating offsets.

Furthermore, the plan requires that all offsets generated through program auspices are verified by an independent third-party, who performs and documents an in-depth review of all program processes and documentation.

PARTICIPATION

Upon enrollment in C3, companies provide West Main Consultants with documentation showing cement usage, SCM usage and concrete manufactured from the immediately preceding three years, and on an ongoing quarterly basis to establish baselines and determine avoided emissions. Companies typically provide documentation in the form of:

* reports from cement and SCM suppliers showing total purchases by quarter and year
* reports provided by the company showing total cubic yards (cy) produced by quarter and year

Established baselines, actual portland cement reductions and CO2 emissions avoided are tracked and reported in quarterly monitoring reports, which are provided to participating producers and The Climate Trust to verify offsets. Upon the delivery to and acceptance by The Climate Trust, incentive payments are paid to companies for verified offsets.

PROGRAM CALCULATIONS

Considering that SCMs may also be used as a strength additive or fine aggregate in concrete mixes, SCM use does not necessarily equal portland cement not used. As a result, the program calculates avoided emissions based on reductions in portland cement use as opposed to increases in SCM use. A company’s avoided CO2 emissions are calculated by first establishing quarterly baseline cement to concrete ratios, based on three years of historical consumption and production data. These baseline ratios are used in quarterly calculations to determine baseline emissions, or the emissions that would have occurred had the company been operating under business-as-usual. Next, actual emissions are calculated utilizing quarterly cement to concrete ratios based only on current consumption and production data. When actual emissions are less than baseline emissions for a quarter, emissions are avoided and are equal to the difference between baseline and actual emissions. Metric tons of avoided emissions translate into offsets at a one-to-one rate (i.e. one offset is equal to one mt of avoided CO2 emissions). The resulting offsets are purchased by The Climate Trust in exchange for incentive payments of $4 per offset paid to producers. The detailed offset calculations below follow a sample company through one quarter of participation.

Establishing Baseline Ratios

Baseline cement to concrete ratios are calculated for each calendar quarter using three years of historical cement usage in tons and cubic yards of concrete manufactured provided by a producer and/or its suppliers. All data is converted to pounds before starting program calculations. Sample historical data for a producer for Quarter 1 after conversion is summarized in the tables below:

<table>
<thead>
<tr>
<th>Cement Used (lbs)</th>
<th>Past Year 1, Q1</th>
<th>Past Year 2, Q1</th>
<th>Past Year 3, Q1</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>15,505,000</td>
<td>16,776,000</td>
<td>15,750,000</td>
<td>15,808,333</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Concrete Manufactured (lbs)</th>
<th>Past Year 1, Q1</th>
<th>Past Year 2, Q1</th>
<th>Past Year 3, Q1</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>103,250,000</td>
<td>109,550,000</td>
<td>107,800,000</td>
<td></td>
<td>106,866,667</td>
</tr>
</tbody>
</table>

The baseline cement to concrete ratio for Quarter 1 is calculated using the 3-year averages of cement used and concrete manufactured.

\[
\text{Baseline Ratio} = \frac{\text{Cement Used (lbs)}}{\text{Concrete Manufactured (lbs)}} = \frac{15,808,333}{106,866,667} = 0.1479
\]
Baseline Emissions

At the end of Quarter 1, cubic yard production data provided by the producer is used in conjunction with the Quarter 1 baseline cement to concrete ratio to determine baseline emissions for the quarter. The table below shows the concrete manufactured for the current year’s Quarter 1 converted to pounds, as well as the baseline cement to concrete ratio for the quarter.

<table>
<thead>
<tr>
<th>Current Concrete Manufactured (lbs)</th>
<th>Baseline Cement to Concrete Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current Year, Q1</td>
<td>12,525,000</td>
</tr>
<tr>
<td></td>
<td>0.1479</td>
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</tbody>
</table>

The baseline emissions for the current Quarter 1 are calculated by multiplying the baseline cement to concrete ratio for the quarter by the program’s established emissions factor of 0.81 mt of CO2, yielding the effective baseline emissions per cubic yard of concrete. This baseline is then multiplied by the amount of concrete manufactured during the current Quarter 1, yielding the emissions that would have been emitted were the company operating under business-as-usual. This result is converted to metric tons (divided by 2204.6), yielding the baseline emissions for the current Quarter 1.

\[
\text{Baseline Emissions} = \frac{112,525,000 \times 0.1479 \times 0.81}{2204.6} = 6.115 \text{ mt}
\]

Actual Emissions

Actual emissions for the current Quarter 1 are determined using the current quarter’s cement to concrete ratio based on actual usage and production data provided by the producer and/or its suppliers. The table below shows the current Quarter 1 cement used and concrete manufactured converted to pounds, as well as the resulting cement to concrete ratio.

<table>
<thead>
<tr>
<th>Current Concrete Used (lbs)</th>
<th>Current Concrete Manufactured (lbs)</th>
<th>Cement to Concrete Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current Year, Q1</td>
<td>12,600,000</td>
<td></td>
</tr>
<tr>
<td></td>
<td>112,525,000</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.1120</td>
<td></td>
</tr>
</tbody>
</table>

Actual emissions for the current Quarter 1 are then calculated similarly to the baseline emissions, but use the current quarter’s cement to concrete ratio.

\[
\text{Actual Emissions} = \frac{112,525,000 \times 0.1120 \times 0.81}{2204.6} = 4.630 \text{ mt}
\]

Calculating Offsets Generated and Incentive Payments

Based on the above information, the producer’s actual emissions for the current Quarter 1 were less than the baseline (business-as-usual) emissions, therefore emissions were avoided and offsets were generated. To calculate avoided emissions, actual emissions are subtracted from baseline emissions and the result is translated into offsets at a one-to-one rate. These offsets are then purchased from the producer by The Climate Trust at $4 per offset.

\[
\text{Avoided Emissions} = 6.115 - 4.630 = 1.485 \text{ mt}
\]

<table>
<thead>
<tr>
<th>Avoided Emissions (mt) or Offsets</th>
<th>1,485</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price per Offset</td>
<td>$4</td>
</tr>
<tr>
<td>Participant’s Incentive Payment</td>
<td>$5,940</td>
</tr>
</tbody>
</table>

A Note Regarding GGBFS Use

In order for the raw byproduct of blast furnace steel production, GGBFS (or slag), to be used as an SCM, it must be processed using several energy-intensive steps. This process results in emissions that otherwise would not occur under business-as-usual, emitting 0.021 mt of CO2 for every metric ton of slag used in concrete production. These emissions are accounted for in program calculations. To simplify these sample calculations, slag was not included.

To account for emissions associated with slag use, both a baseline and current slag to concrete ratio are calculated and multiplied by 0.021 mt of CO2 to determine emissions due to slag used per cubic yard of concrete. These emissions are then added to the baseline and actual emissions due to cement used per cubic yard of concrete before being multiplied by the current amount of concrete manufactured.

As an example, suppose the sample company in the above calculations did not use slag during the last three years, but started using slag in the current Quarter 1, then the baseline emissions calculated above would remain the same (6,115 mt). However, if the participant used 3,208,333 lbs of slag to replace portland cement, then actual emissions would be 4,661 mt.

\[
\text{Avoided Emissions} = 6.115 - 4.661 = 1.454 \text{ mt}
\]

<table>
<thead>
<tr>
<th>Avoided Emissions (mt) or Offsets</th>
<th>1,454</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price per Offset</td>
<td>$4</td>
</tr>
<tr>
<td>Participant’s Incentive Payment</td>
<td>$5,816</td>
</tr>
</tbody>
</table>

POTENTIAL OFFSETS

The force behind offset generation in the C3 program is the reduction of portland cement use relative to concrete produced. For this reason, all cement use data is translated into cement to concrete ratios before being used in program calculations. Consider a different scenario for the above sample company, who manufactured an average of
approximately 27,000 cy (106,866,667 lbs) of concrete using an average of approximately 7,900 tons (15,808,333 lbs) of portland cement during the past three years, yielding a baseline cement to concrete ratio of 0.1479. If the company manufactures 25,000 cy (100,000,000 lbs) of concrete in Quarter 1 of the current year and reduces cement usage by 10% below their historical average use to 7,110 tons (14,220,000 lbs), the current cement to concrete ratio is 0.1422. When this 10% cement use reduction is considered relative to the company’s concrete produced, it translates to a cement to concrete ratio reduction of 3.8% (see calculation below) and will yield 208 mt of avoided emissions.

\[
\text{Cement to Concrete Ratio Reduction (\%)} = \frac{0.14/0.1422 - 0.1479}{0.1479} \times 100 = 3.8\%
\]

The graph below illustrates the potential avoided emissions and offsets generated by the sample company for Quarter 1 of the current year at various cement to concrete ratio reduction levels, assuming no slag use.

**BENEFITS**

The program provides several other benefits beyond incentive payments for participating companies, including custom analytical tools, sustainability performance tracking and documentation, and reciprocal marketing opportunities.

To assist companies in taking full advantage of participation, West Main Consultants develops a custom analytical tool to evaluate potential offsets and incentives that could be generated at various predetermined portland cement reduction levels based on a producer’s historical consumption and production data. Another portion of the tool serves as a calculator that estimates potential offsets and incentives based on user inputs. These tools can be used to explore and establish cement reduction targets, and as companies strive to improve sustainability, they can be used to better understand the correlation between cement reduction and offset generation and may also prove useful in establishing sustainability goals.

As sustainability continues to become increasingly important in the market place, it is key that companies track and support their sustainability efforts. The C3 program documents baseline portland cement use, actual cement reductions and CO2 emissions avoided for each program participant in quarterly monitoring reports for offset verification purposes. These third-party verified, performance-based reports can also serve as a company’s mechanism to track and document progress towards corporate sustainability goals and may provide quantifiable milestones for companies interested in reducing their carbon footprint.

Participating companies also have the opportunity to gain recognition for actively pursuing their sustainability efforts by displaying their company logos, together with brief company descriptions and links to their websites, on the program’s website. In addition, the program provides companies with the program logo to assist in their individual marketing efforts.

By capitalizing on the innovative use of SCMs through the C3 program, concrete producers are not only receiving program benefits, but are playing their part to further the economic and environmental sustainability goals of the concrete industry as a whole through mix ingredient optimization, program incentives, utilizing industrial byproducts, and reducing portland cement use.

For more information, visit www.coolclimateconcrete.com or contact Lura Schmoyer at schmoyer@wm-consultants.com or 610.683.5730. The views and opinions expressed in this article are those of the author(s) and do not necessarily reflect the views and opinions of the National Ready Mixed Concrete Association.
Environmental Excellence Awards – What Makes a Winner?

By Douglas Ruhlin, Principal Environmental Consultant, Resource Management Associates

The 2010 Environmental Excellence Awards were recently announced (see sidebar for award winners), and congratulations to all award recipients. This year, as in past years, an outstanding group of concrete producers have been recognized for their efforts in striving for, and achieving, environmental excellence. As a longstanding judge in this award program (one of the most popular and competitive NRMCA runs), I can attest that this year’s judging was among the most difficult – all applicants submitted were truly outstanding and clearly indicate an incredibly high level of environmental achievement and commitment.

What sort of attributes do these outstanding facilities have in common? Here are some noteworthy examples shared by nearly all applicants in this year’s award program:

• A clearly documented baseline of complete regulatory compliance. These plants know what permits and approvals they need, have them and comply with their requirements. This is usually evidenced by a lack of enforcement actions.

• Outstanding aesthetic conditions. These plants look great, and the plant and company are committed to keeping them that way. Typically, this includes great looking equipment, landscaping and green space, clean work areas, etc.

• Well designed documentation systems and training programs. Usually, not only do these plants have the documentation expected to be present (such as Stormwater Pollution Prevention Plans and SPCC plans), but they also have Environmental Management Systems, emergency management plans, training programs including driver training (many with CDP programs), etc.

• Clearly evident corporate and management commitment to an ongoing environmental program. It’s generally pretty clear that striving for environmental excellence is a part of the plant and corporate culture, not a passing fad or new program designed solely for marketing purposes.

• A vision of the future of environmental issues. This includes moving beyond present regulatory issues to areas such as corporate sustainability efforts, green product developments, environmental marketing, environmental outreach, etc.

So how then does a judge separate one outstanding applicant from another? What does it take to become an Environmental Excellence Award winner? Here are some thoughts and tips from a longtime judge:

1. Stick to the format. NRMCA provides an electronic application form with form blocks to be written in for a reason. Applications with long attachment files likely won’t get the attention that applicants think they might. Use the application form, and if you feel you must attach additional information, keep it brief and to the point.

2. Review your photographs carefully. All judges can recount instances of photographs that presented an unintended result, such as newly installed fuel tanks that looked great but that also showed heavily stained fueling areas. Or, photographs that are unclear as to what is being illustrated (captions are very helpful), or photographs that aren’t very attractive. You’re only allowed a finite number of photographs – make sure they’re good ones.

3. Do not “cookie cutter” multiple applications if you send in more than one. This gets the judge’s notice and is not rewarded – in fact, it can be penalized. This can give the appearance of a lack of specific plant factors and usually works against the application. Make sure each application is uniquely written and addresses specific plant considerations.

4. Don’t overemphasize corporate programs that aren’t implemented at the specific applicant plant. It’s nice to know, but not really that relevant to the plant in question. If it’s important to the overall understanding of plant operations, it should be mentioned, but it has to be relevant.

5. Tell us what is unique about your plant and its operations, don’t feel you need to detail the obvious and commonplace. Today, all plants (hopefully) have an NPDES permit, SPCC plan (when needed) and air permits. This doesn’t make award winners unique, so don’t overly elaborate on these issues (although don’t ignore mentioning them – if they’re
NRMCA Announces Winners of 2010 Environmental Excellence Awards

The National Ready Mixed Concrete Association’s Commitment to Environmental Excellence Awards competition offers producers national recognition for outstanding contributions to protecting the environment and maintaining sound management practice in their operations. Now in its 15th year, the program salutes companies that have not only met, but surpassed, governmental compliance measures and demonstrated a commitment to environmental excellence through plant and staff investment. Competing plants enter one of four categories depending on the amount of concrete produced in calendar year 2009.

Winning entrants will be honored at an awards presentation ceremony at NRMCA’s ConcreteWorks this fall. Winning and Honorable Mention facilities will also be featured in an edition of Concrete Products magazine.

Category A: Less than 25,000 cubic yards of concrete produced:

<table>
<thead>
<tr>
<th>Company</th>
<th>Plant Location</th>
<th>Award Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>CEMEX</td>
<td>Fort Mill, SC</td>
<td>1st Place</td>
</tr>
<tr>
<td>Transit Mix Concrete and Materials Company</td>
<td>Lockart, TX</td>
<td>2nd Place</td>
</tr>
<tr>
<td>Staker Parson, an Oldcastle Company</td>
<td>Tucson, AZ</td>
<td>3rd Place</td>
</tr>
<tr>
<td>CEMEX</td>
<td>Bunnell, FL</td>
<td>Honorable Mention</td>
</tr>
<tr>
<td>Idaho Concrete Company, an Oldcastle Company</td>
<td>Ketchum, ID</td>
<td>Honorable Mention</td>
</tr>
</tbody>
</table>

Category B: Greater than 25,001 but less than 50,000 cubic yards of concrete produced:

<table>
<thead>
<tr>
<th>Company</th>
<th>Plant Location</th>
<th>Award Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transit Mix Concrete and Materials Company</td>
<td>Huntsville, TX</td>
<td>1st Place</td>
</tr>
<tr>
<td>Transit Mix Concrete and Materials Company</td>
<td>Leander, TX</td>
<td>2nd Place</td>
</tr>
<tr>
<td>Transit Mix Concrete and Materials Company</td>
<td>Georgetown, TX</td>
<td>3rd Place</td>
</tr>
<tr>
<td>Staker Parson, an Oldcastle Company</td>
<td>Tucson, AZ</td>
<td>Honorable Mention</td>
</tr>
<tr>
<td>Pete Lien &amp; Sons</td>
<td>Rapid City, SD</td>
<td>Honorable Mention</td>
</tr>
</tbody>
</table>

Visit our Buyers’ Guide online at NRMCA.OfficialBuyersGuide.net
not listed, judges will wonder whether you have your regulatory bases covered). Instead, tell us how you go beyond the scope of what’s required, into novel and interesting areas. Do you recycle your process water? Do you capture (harvest) stormwater for use in concrete batching? Do you use pervious concrete on your plant site? Do you use alternative energy at your plant? What makes you unique? And, consider that practices that were commonplace only a few years back are now becoming less common amongst applicants, such as permitted discharges at a plant site. This also applies to operating challenges being faced by the plant – what makes your challenges unique relative to others?

6. If your plant has received Green-Star certification clearly state it in the application. Judges will also be looking at your application to see how your Green-Star processes are mentioned throughout, such as expecting to see a discussion of your Environmental Management System in appropriate sections of the application.

7. Don’t presume that judges can “read between the lines”. We can’t. It’s important to remember that the only thing your application will be judged on is the application itself. Take time with it. Write it carefully and specific to the plant in question. Make sure you’ve covered what’s important and leave out what’s not. Check your spelling and grammar. Have someone familiar with concrete environmental matters and your plant take a hard, critical look at your application and act on any advice you get. Look your pictures over with a critical eye. Don’t be overly brief (how can you adequately describe what makes your program unique in a sentence or two), but don’t be overly long. Put yourself in the judge’s shoes, and pretend you are reviewing your application – does it seem too long to you?

8. Ask questions about the application if unsure. NRMCA staff and present and past judges (including myself) can be a great source of general information on completing the application, what is being requested and how best to provide information in response. No one will receive any “inside information” (there isn’t any), and you’ll be told the same thing others will upon request. But if you’re not sure, ask. Your benefit will be a better application.

9. Lastly, if you didn’t win in a given year, come back the following year. There are NO losers in the NRMCA Environmental Excellence Award process. Typically, the margin between those who receive awards and those who don’t is very slim. The judges remember who wins and who doesn’t, and if a plant tries in more than one year, particularly if there has been some improvement in either the plant or the application, a re-submittal has a great chance of winning.

Nearly every plant submitted as an application is an outstanding one and a winner in its own right, and particularly so this past year during the 2010 Awards. The differentiation between those that receive awards and those that have to come back next year can be quite slim. Consider the tips above, prepare a great application and you too might be in the winner’s circle next year.

For further information on any of the issues in this article, Doug Ruhlin can be contacted at Resource Management Associates, PO Box 512, Forked Rover, NJ 08731; (609) 693-8301; www.resourcemanagement.com or via e-mail at druhlin@resourcemanagementassoc.com.

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**Category C:** Greater than 50,001 but less than 100,000 cubic yards of concrete produced:

<table>
<thead>
<tr>
<th>Company</th>
<th>Plant Location</th>
<th>Award Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aggregate Industries</td>
<td>Golden, CO</td>
<td>1st Place</td>
</tr>
<tr>
<td>Dolese Brothers</td>
<td>Midwest City, OK</td>
<td>2nd Place</td>
</tr>
<tr>
<td>Dolese Brothers</td>
<td>Norman, OK</td>
<td>3rd Place</td>
</tr>
<tr>
<td>CEMEX</td>
<td>Hudson, FL</td>
<td>Honorable Mention</td>
</tr>
</tbody>
</table>

**Category D:** Greater than 100,001 but less than 200,000 cubic yards of concrete produced:

<table>
<thead>
<tr>
<th>Company</th>
<th>Plant Location</th>
<th>Award Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dolese Brothers</td>
<td>Edmund, OK</td>
<td>1st Place</td>
</tr>
<tr>
<td>Aggregate Industries</td>
<td>Minneapolis, MN</td>
<td>2nd Place</td>
</tr>
<tr>
<td>Dolese Brothers</td>
<td>Oklahoma City, OK</td>
<td>3rd Place</td>
</tr>
<tr>
<td>Bode Concrete</td>
<td>San Francisco</td>
<td>Honorable Mention</td>
</tr>
</tbody>
</table>
How Does Your Quality Control Department Affect Your Company?

By Fernando Rodriguez, II

Mix designs, production plants, specifications, admixtures and raw materials have changed so much in the last few years that the need for a good concrete quality control department is paramount. In my opinion, the quality control (QC) department is the most critical group in the ready mixed concrete industry. The QC and/or engineering department should be involved in every aspect of the business and particularly in the production portion of the company.

The QC department is involved in every step of concrete production. The QC technician is usually the first person at the plant prior to the commencement of the day’s production. The QC technician works closely with the loader operator, the batch man and the concrete delivery professionals (CDP) before, during and after the day’s production. The QC technician starts off with confirming the aggregate moistures and ensuring that the stockpiles are well maintained and free of contamination. The QC technician can confirm entrained air contents, slump specifications and admixture dosage rates for the batch man. Once the raw materials have been placed in the truck mixer, the QC technician can assist the CDP in adjusting the concrete’s slump prior to leaving the plant. The technician can interpret any problems with the concrete prior to the CDP leaving the plant. They can then make the necessary adjustments to the mix prior to loading the next truck.

The QC department also works closely with the dispatchers on daily orders and schedules. The technician can give the dispatchers information about the site, the accessibility to the site and even personnel dynamics. The technician can even help smooth over the more demanding customer. The technician can confirm the mix designs to be used at the project.

The QC group can also serve as an early warning system for the fleet manager. Mixer drums that need to be chipped out or non-functioning back-up alarms are all problems that can affect the delivery of the load. As the technician is checking loads leaving the plant, he or she can identify these problems and have them corrected as soon as possible.

Some of the ready mix companies in the U.S. also own or work closely with an aggregate producer. The ready mix technician can also help provide a quality assurance-type testing at the quarries. Most technicians are required to test the aggregate on a daily basis. The QC department can take samples of the area that is currently being mined to determine if good ASTM C33 sand can be made from it.

The QC manager/engineer can help in reducing costs to current mixes by establishing optimization programs. This can be done by constantly reviewing the performance of popular mixes. The average compressive strength, standard deviation and cusum are statistical tools that can be used to measure the performance of the mixes. However, care should be taken to not misinterpret the data or use it as a blanket assessment of the performance of the mix for several plants using different raw material. Utilizing new material, supplementary cementitious materials and new admixture can enhance the performance of existing mixes and therefore allow the QC manager/engineer to reduce certain materials, use substitutes, or use new combinations of material to reduce costs.

It is extremely difficult to attach a dollar amount to the savings the QC department accumulates over the year, unless certain parameters are set up. For example, tracking the amount of fly ash used in lieu of Portland cement. Unless every technician keeps a detailed diary of his or her daily activities which includes saved loads, how can a dollar amount be associated to the QC department? How does a general manager quantify the savings generated by the department? About six months ago, I took Anthony “Bubba” Barwick, QC technician for Aggregate Industries, to lunch and during that time he received a phone call from a contractor. The contractor was informing Anthony that a load of concrete was “too wet” and was in jeopardy of being rejected by the inspector. Anthony knew that the mix had an elevated slump due to the admixtures and not because of extra water added to the load. He was able to relay this information to the inspector and they decided to make an extra set of compressive strength specimens and place the concrete. How does a general manager put a value to the personal relationship established by the technicians and contractors? Can a dollar amount be placed on these relationships? Not in my opinion.

The QC department can also help in enforcing safety policies. Keeping in mind that the technicians are either in the field or at their assigned plants, they have constant contact with CDPs. The technician can remind personnel to wear their vests, hard hats and eye protection while on the site and even while on the company property.

QC personnel have even been known to help “sling” ice, place fibers in a batch, run a load and even batch concrete. It has been my experience that plant operations personnel rely on a technician for everything from mix expertise to simply an extra pair of eyes and hands at the plant.

Instead of asking which department the QC group helps in, one should ask which department does the QC group not help in? As stated before and in previous articles, the QC department is the most critical group in the ready mixed industry. It affects all parts of the company and it contributes greatly to all those involved from the loader operator to the general manager.

For more information, contact Mr. Rodriguez at concretemechanics@gmail.com.