

The Use of Slag Cement in Architectural Concrete

By Paul Brooks, Product Manager

St. Lawrence Cement Co., LLC, Albany, NY

Concrete, whether cast-in-place or precast, provides a versatile of building material for countless applications. Taking this idea a step further is its use in architectural concrete. Besides being placed in ways that would make other building products cost prohibitive, concrete provides a durable and low maintenance form of building.

Perhaps most importantly to architects, concrete does not have to be limited to the same gray to which most of us are accustomed. The use of white or custom colored concrete has enabled architects to design structures that can make a unique and lasting impression. Concrete in this form has eliminated the need of costly painting with its constant demand for maintenance.

One of the more common materials in architectural concrete is white cement. White cement has the same performance characteristics as ordinary portland cement and requires no special adjustments to the concrete mix design. White cement is composed of specific raw materials, which have only slight amounts of the iron and manganese oxides that are responsible for the gray color of ordinary portland cement. White cement even if used in combination with color additives can brighten the look of the concrete and in some cases can allow for smaller color doses. White cement, like white colors on a paint chart, can vary from a buff or cream tone to a blue or greenish hue. Because of these subtle variations, only the same type/brand of white cement produced at the same mill should be used once the job begins.

Integral colors designed for concrete applications can greatly enhance the uniqueness of a structure by the addition of mineral oxide pigments which can be used with either gray or white cement during the batching process. White or brightly colored concrete can reduce energy costs by being more light reflective thus requiring less artificial lighting. Lighter structures can also stand out more prominently from surrounding buildings and the fine details of the architecture can be viewed more easily.

Chemical admixtures can be used as effectively as they are used in conventional concrete applications although some can cause surface discoloration. However, the need for smooth unblemished surfaces makes the use of chemical admixtures even more important

White pozzolans and slag can also make great contributions to an architectural structure. Besides contributing to a more pleasing appearance, they can be used to enhance the performance characteristics of high performance concrete for greater strength, better resistance to ingress of discoloring moisture, and limitation of unsightly efflorescence.

Slag may temporarily give off a bluish or greenish tint, but a short exposure to the environment will dissipate this coloring and ultimately bring out slag's brilliant white coloring. Special consideration should be given to aggregate selection as this can also influence color variation. Lighter coarse and fine aggregates are desirable as they will help to prevent shading and an elevated sand content will help to maintain a more uniform hue.

Form type is also important as untreated wood forms will absorb water from the concrete and darken the localized areas. For this reason, non-absorptive forms are advised. Joints should be sealed to prevent leakage, and forms should be left in place for as long as possible and only should be removed in the same time sequence as placed. Because some form oils can influence color, care should be taken in their selection.

To provide consistency in appearance, great care should be taken to use consistent materials, while also batching, placing and finishing in a consistent manner. Variations in water cement ratio can have a detrimental affect on consistency, as a lower ratio will produce a deeper color than a higher w/c ratio. Most important to the job success is the use of a mockup panel using all proposed materials to provide the designer with an actual example of the expected concrete color.

One of the best examples of an architectural concrete structure is the Rock and Roll Hall of Fame in Cleveland, OH. The designers of this structure wanted something that could match the creativity of those honored within its walls. However, this design created some unique challenges. First, they wanted the building to be bright in color but did not want the continual maintenance of painting a normal gray structure. As the price of white cement in the Cleveland area was much more expensive than gray portland cement, they looked for other alternatives and decided upon slag cement in combination with a light gray portland to provide a bright color for the structure.

Besides whiteness, other attributes of slag cement played a part in the decision. In addition to greater strength, slag minimized efflorescence, thus avoiding any potential discoloration from this reaction. Since portions of the structure required mass concrete, slag was also helpful in lowering the heat of hydration to avoid thermal cracking. A substitution rate of 30% slag was used in the structural concrete and a 70% rate was used for the mass concrete section.

Colored mockups were made prior to the actual pour to get an idea of the final color of concrete and were approved by the architect.

Harvard University used architectural concrete for its new Life Sciences Building. This was intended to be both aesthetically pleasing and structurally supportive. Mockups were used to determine the most desirable mix. It was decided to use a half dose of beige pigment along with a combination of white cement and 45% slag. This color combination allowed the structure to match the color of the older and well-established surrounding buildings and thus blend in with its surroundings. Slag was also chosen due to its positive impact on strength gain for high strength requirements.

Creative use of concrete can provide the architect with a unique and lasting means of expression and design. To achieve a true custom look, materials such as white cement, colored pigment and slag cement help to provide greater versatility. Slag cement, besides providing an alternative to white cement, can offer greater strength and durability to the project. As higher demands of concrete are used in this application, it is even more important to follow proper but basic procedures to ensure that the results meet the expectations of the job.