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Features

Economic Impact of Recycled Concrete Aggregates

By Abdul Rahman Al Blooshi
Technical Engineer

With the increase in economic growth, population growth and the expansion of urban areas, the city has been demarcated and roads have been paved. The need for construction, urban expansion and the construction of new buildings have increased. This has led to a significant increase in the use of concrete. The use of concrete is estimated at 30 billion metric tons Year in the world, and so it plays an important role in the development of the economy of countries. However, the increase in demand for the use and production of concrete is offset by a shortage of good raw materials on our land. The concrete industry consumes a large amount of natural raw materials and this has a direct impact on the environment and consumption of energy and economy.

In addition, urban development coincided with the demolition of old buildings and structures, and thus the accumulation and production of huge amounts of waste, which represent the old concrete, the largest part in addition to metals, wood, glass, ceramics and others.

The economic analysis of the recycled concrete aggregates follows a life-cycle cost. The approach focuses on three specific costs of interests adopted from *"User Guidelines for Byproducts and Secondary Use Materials in Pavement Construction."*

The three cost categories include:

1) Cost of material
2) Cost of installation
3) The life-cycle cost

Cost of material (DP)
For this situation, the cost of material incorporates, yet is not constrained to, the cost that the buyer would pay to have the solid total delivered to a venture site. The cost of material can then be distinguished as the delivered price (DP). The delivered price (DP) is the gathered aggregate of the accompanying things: the price of the raw material (RM), cost of processing (PR), cost of stockpiling (ST), cost of loading (LD), cost of transporting (TR), and profit (P).

An Equation have been developed to shows the aggregate fixings required with the cost of material

DP = RM + PR + ST + LD + TR + P

based on this equation, it is important to clarify and determine the parameters that includes in the equation.

The price of row martials (RM) depend weather it's from the supplier or it's from the own company. *"The cost of processing (PR) the material includes the costs associated with manufacturing the product. For instance, primary and secondary separation, crushing, screening and drying would be included in the processing costs for RCA"* (3).
After the process, the prices where the products stored or stockpiled (ST) until it can be used for construction. The cost of loading (LD) where it's the cost of delivering the products, the distance and the Truck required for delivery. Cost of transporting (TR) can be determined normally by significant part of overall the (DP).

based on the research, the most important things are the Profit (P). where it can be determined by two ways:

1) The seller can either add (P) to the cost of delivery
2) Discount (RM)

Cost of Installation (CI)

CI = DR + CC + RP

This equation can be normally explaining as the cost of Installation will be the summation of the cost of the Design(DR), construction (CC) and testing (RP).
(DR) represents the specific amount of time and effort involved in designing the base of the structure For Both weather its recycled or Fresh Aggregates. (CC) is the activity and the activity that happen during the installation whether its recycled of Fresh Aggregates. (RP) which is normally represent the cost of testing the materials whether its Fresh or Recycled.

Life-Cycle Cost

At the point when either the yearly maintains expenses or length of item life varies. A life cycle cost is necessarily to determine the cost-benefit comparison of recycled and fresh used in a certain project.

$$EC = CI*(CRF) + AM$$

The effective cost (EC) resulting a calculation of Annual maintains cost and the CRF which it's a fixed interest rate the can be calculated by the equation below

$$CRF = (i (1 + i)^n)/ ((1 + i)^n – 1)$$

in the table below there will be an example of the compression between using RCA and Fresh Aggregates in a highway construction project in Winter Haven, Florida that will normally can be distinguished the differences between using Fresh or RCA.

Normally as we can see in the table that the use of RCA in the project is economically sustainable.

Conclusion

This paper describes the economic impact of using the RCA which normally appear in the research have been study for using RCA instead of Fresh Aggregates in Highway project in Florida.

There will be Differences for using this study from country to country depending on the different cost for each parameter on every equation has been conducted.

The main point of this paper is to prove that is it worth using RCA based on economical side and whether if it will gain the company profit or loss.

As its describe in the paper, the three important cost categories should be including: 1- cost of martials. 2- cost of installation. 3- Life-cycle cost where we use the RCA

Based on the calculation we can decide if the RCA is an important to use instead of fresh aggregate that will give the company profit more than fresh aggregate that it's gave.

	Recycled Concreted Aggregate ($USD per ton)	Virgin Limerock Aggregate ($USD per ton)
Cost of Material		
Delivered Price (DP)	12.75	13.20
Price of Raw Material, F.O.B. (RM)	0.00	2.00
Cost of Processing the Material (PR)	3.00	3.00
Cost of Stockpiling the Material (ST)	0.50	0.50
Cost of Loading the Material (LD)	0.50	0.50
Cost of Transporting the Material (TR)	2.75	6.00
Profit (P)	6.00	1.20
Cost of Installation		
Cost for Design of Application with Material (DR)	0.00	0.00
Cost for Construction with Material (CC)	3.75	4.50
Cost of Testing and Inspection for Proposed Application (RP)	0.70	1.00
Sub-Total Cost of Installation (CI)	4.45	5.50
Life-cycle Cost		
Annual Effective Cost (EC)	1.66	1.82
Cost of Installation (CI)	4.45	5.50
Capital Revovery Factor (CRF)	0.15	0.15
Annual Maintenance Cost (AM)	1.00	1.00

References:

1) *The Cement Sustainability Initiative 2009, https://www.soas.ac.uk/cedep-demos/000_P508_EAEMS_K3736-Demo/casestudies/media/CS!-Res2%20CSI-RecyclingConcrete-FullReport.pdf*

2) *User Guidelines for Byproducts and Secondary Use Materials in Pavement Construction: Evaluation Guidance, Cost Issues. Recycled Material Resource Center. www.recycledmaterials.org/tools/uguidelines/cost.asp. Accessed May 26, 2010.*

3) *International Journal of Advanced Science and Technology Vol.77 (2015), pp.7-24 http://dx.doi.org/10.14257/ijast.2015.77.02*

4) *Sustainable Assessment of Recycled Concrete Aggregate (RCA) Used in Highway Construction. Jeff Donalson, Raymond Curtis, Dr. Fazil T. Najaf November 15, 2010.*

Usage of Blended/Special Cements in optimizing Mortar and Blocks

By Ayman Basha
Grinding Manager

Blends can offer significant performance advantages for Mortar and blocks businesses. They can produce stronger and more durable Mortar & Blocks. And they have a long and impressive track record. The materials used in blends have been around for nearly a century and have withstood the test of time. Fly ash, for example, was used in the construction of the Hoover Dam in the 1930s. Blends are also suitable for harsh environments where concrete is likely to be exposed to moisture, extreme weather and chemicals. And they are environmentally friendly products that can help projects meet sustainable development objectives.

Specifiers who haven't worked with blended cements can find considerable technical support and documentation on performance in published literature. In most cases, blends can be specified as a direct replacement for Portland cement on a one-to-one basis.

Types of Blends

Blends, as the names implies, are a mixture of multiple ingredients. They combine Portland cement with one or more supplemental cementitious material (SCM). SCM's can be added easily as one of the blended cement components. The most common SCM's are:

- GGBFS (Ground Granulated Blast Furnace Slag), commonly known as slag cement, which is a byproduct of the iron manufacturing process.
- Fly ash, which comes from pollution-control equipment of coal-burning power plants.
- Silica fume, a byproduct of manufacturing silicon metals and Ferro-Silicon alloys.

There are two main categories of blends: binary and ternary. Binary, as the name implies is a mixture of two products, Portland and one SCM. Whereas the ternary blend is a mixture of three products, Portland and two SCM's. The type and proportion of SCM included in the blend establishes the performance in the needed mix for Mortar or Blocks. Silica fume, as an example, is generally specified in specialized applications requiring high strength and/or low permeability.

Used in the correct proportions, fly ash, slag or silica fume individually improve the performance of needed mix. When used together, in ternary blends, their effects are synergistic.

Why blends perform better

Portland cement, slag and fly ash share chemical similarities. They all contain similar oxides, though the proportions are different (Table 1). Slag particles are amorphous, glassy particles that are smaller than those of Portland cement. The round shape of fly ash is also beneficial. These chemical and physical properties improve performance in a number of areas:

Reduced Permeability

Blended cements can significantly extend the life of Mortar and Block mixes because they can reduce the permeability of water, chlorides and other aggressive agents.

In part, this reduced permeability results from improved particle packing due to the slag, fly ash or silica fume particles. Additionally, the chemical reaction of the silica in the SCM with the calcium hydroxide produced during the hydration of Portland cement, produces additional C-S-H, infilling voids and reducing permeability. C-S-H is the "glue" that makes up the paste of Mortar and Blocks.

Improved Workability

The spherical shape of fly ash particles and the glassy nature of slag particles reduce the amount of water needed to produce workable concrete. This also enhances the pump-ability of Mortar mixes through the mixing machine pumping system, allowing it to flow more easily. Blended cements are easier to place, finish and consolidate.
Blended cements tend to have slower set times than Portland cement, which can be a benefit during the warmer months when most projects takes place. In hot weather, for example, the slower set times give crews more time to place and finish Mortar surface within acceptable time.

Curing

As with all mixes, proper curing is essential to achieve the best performance. Curing practices used with Portland cement are appropriate for blends as well.

Enhanced Strength

Blends can improve long-term strength development, depending on the proportions and materials used. Final strength of Blocks & applied Mortars are directly related to the amount of water used in the mix (water-cement ratio). By reducing the amount of water required, blends produce stronger concrete. In addition, the slag, fly ash and silica fume in blends react with Portland cement, converting calcium hydroxide $Ca(OH)_2$ into calcium silicate hydrate (C-S-H). C-S-H gives cement its strength, while calcium hydroxide contributes nothing to strength. By producing more C-S-H, blends create higher strengths.

Resistance to Sulfate Attack

Sulfates, which are present in seawater, wastewater and some soils, can react with the alumina in Portland cement, causing expansion. Blends can offer superior resistance to these attacks because they contain fewer of the compounds that react with sulfates, and because their low permeability keeps sulfate-bearing waters out. So Mortar mixes exhibits higher durability characteristics when we use blended cements.

Resistance To Alkali-silica Reactions

Alkali-silica reactions (ASRs) occur between the alkalis in Portland cement and certain silica aggregates. In the presence of water, they can form an expansive gel that can lead to cracking. Blends combat ASR in three ways:

1. SCMs can reduce the alkali loading in the mixes, as generally SCMs contain fewer alkalis than OPC.
2. The fly ash and slag in blends also react with the alkalis, making them unavailable for the reaction.
3. Lower permeability reduces the ingress of water.

Specifying Blends

Blends can be introduced to obtain superior results. As a general rule, blends can be substituted on a one-to-one basis for Portland cement.

In addition, manufacturers as grinding plant of SRMCC will provide technical assistance to help in development or modification of internal specifications for mixes in order to supply blended cements that allows other business units (Mortar and Blocks) to optimize the performance of its products.

Color

The color of the Mortar can be effected by the use of SCMs but this is dependent on the type and proportions used. Slag produces a lighter products with high reflectivity and is often specified for this reason. Class C and Class F fly ash can produce buff or darker gray products.

Sourcing

Mortar and Block plants normally don't have enough silos for all types of SCM's but SRMCC grinding facility can supply blends with a high degree of consistency, rigorous quality control measures, testing and certification. This will support Mortar and block operations efficiently with more durable products.

Performance-based Specifications

Often, the best approach for specifiers is to move from materials-based specifications to a performance-based specification, allowing contractors greater control over choosing the specific blend.

Industry associations and manufacturers can assist in creating performance-based specifications that offer greater flexibility for materials selection while ensuring that the product will meet performance objectives. For example, if a specifier has experience with a certain type of Portland cement, a manufacturer can recommend equivalent blends that provides equal or better performance, often at a lower cost.

Standards & Nomenclature

Blended hydraulic cements conform to the requirements of ASTM C595 or C1157.

ASTM C595 cements are as follows:

- Type IS: portland/slag cement (25 % to 70% Slag)
- Type IP and Type P: portland-pozzolan cement (15% to 40% pozzolan)
- Type S: slag cement (>70% Slag)
- Type I (PM): pozzolan-modified portland cement (<15% pozzolan)
- Type I (SM): slag-modified portland cement. (<25% Slag)

These blended cements may also be designated as air-entraining, moderate sulfate resistant, or with moderate or low heat of hydration.

ASTM C1157 blended hydraulic cements include the following:

- Type GU: blended hydraulic cement for general construction.
- Type HE: high-early-strength cement.
- Type MS: moderate sulfate resistant cement.
- Type HS: high sulfate-resistant cement.
- Type MH: moderate heat of hydration cement.
- Type LH: low heat of hydration cement.

These cements can also be designated for low reactivity (option R) with alkali-reactive aggregates. There are no restrictions as to the composition of the C1157 cements. The manufacturer can optimize ingredients, such as pozzolans and slags, to optimize for particular mix properties.

The most common blended cements available are Types IP and IS. Source: Portland Cement Association.

These blends will be used to improve quality of our produced Mortar to be the most competitive in the market, by improving workability, durability and reduce possibility of cracking. Also for our Blocks manufacturing the bearing strength and cost will be optimized to a higher extent.

Table 1: Typical chemical oxides for various cementitious materials. (Source: Slag Cement Association.)

	Portland Cement	Slag Cement	Fly Ash C	Fly Ash F
CaO	65	45	25	3
SiO2	20	33	37	58
Al2O3	4	10	16	20
Fe2O3	3	1	7	10
MgO	3	6	7	1

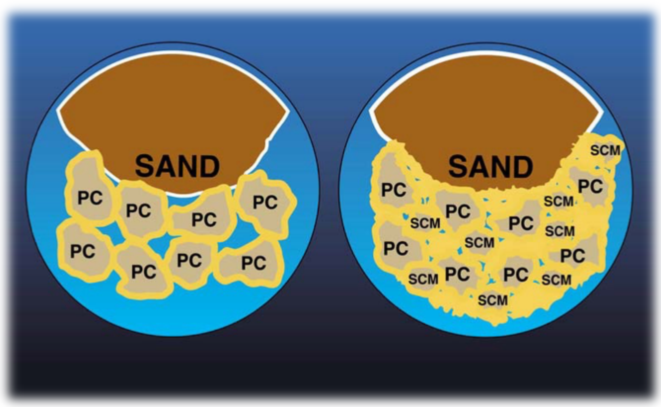

Figure 1.
(Left) When ordinary Portland cement (PC) hydrates, C-S-H is formed (yellow); this glue holds mix paste together. However, gaps in this glue provide pathways for moisture to penetrate and reduce strength.
(Right) When supplementary cementitious materials (SCM) are added (Blended Cements), particles pack more tightly within the voids and additional glue forms from the SCM hydration process. With fewer voids, the mix for Mortar and Blocks is less permeable (Durable) and stronger.

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