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Civil engineering design for green building

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Improved stormwater management and water quality

By Charlene Harper, P.E.



A rainwater cistern feeds this water feature, which fills bioretention planters at [1050 K Street in Washington, D.C.](#)

When people hear buzz about the green building movement, they often think of low-flow showers and waterless urinals; alternative power sources such as solar or wind; and green power credits. Yes, the green building movement is about all of these things, but also so much more. Minimizing the environmental impacts of land development also includes protecting natural systems, reducing impervious footprints, and keeping stormwater in check. That's where we come in: the civil engineers.

In the green building movement, our role as civil engineers is significant and multifaceted. It requires us to integrate sustainability goals into every step of design, from site layout and materials selection to stormwater management and erosion control. It is our responsibility to study the ramifications of design decisions from the perspective of environmental impact, as well as cost, maintenance, and practicality. By adopting some of these methods as standard design practice, we can reduce the impact of all site development, not just the projects that are "going green."

Stormwater system design

The stormwater arena — management, harvesting, and quality — is probably the most obvious civil engineering contribution to green design. Stormwater models are the metric for quantifying the benefits of integrating layout, materials, and management to minimize the development footprint. Land development displaces nature, so beginning design with a stormwater concept plan is the key to mitigating the effects of that displacement.

For example, hydrologic patterns and areas of infiltratable soils should be protected in much the same way as wetlands and floodplains. These elements become especially important as more localities move toward adoption of runoff-reduction methods, low-impact development ordinances, and the pursuit of U.S. Green Building Council Leadership in Energy and Environmental Design (LEED) certification.

Additionally, in recognition of the fact that integrated management practices will never completely replace stormwater management ponds, designs that include forebays, aquatic benches, and adequate hydrology must be standard for all wet pond designs to help alleviate sediment re-suspension, temperature increases, and oxygenation issues.

Current efforts to treat water “where it falls,” and thereby recreate the natural water cycle, stem from the realization that the post-development flows, volumes, and velocities of small, frequent storm events are in fact the most detrimental to downstream systems. There are simple, cost-effective ways to reduce impacts from all project types by incorporating such techniques as disconnecting impervious surfaces and using grassed filter strips and swales to encourage recharge and lower infrastructure costs.

Another tactic is that designers are helping green residential developments strive to minimize disturbance using site fingerprinting and clustering techniques as a means to maximize undisturbed natural areas without sacrificing lot yield. These methods also can be effective to decrease construction and grading costs while maintaining natural habitat, reducing stormwater requirements, and enticing residents to experience nature in their own backyards.

During commercial or industrial project planning, consideration should be given to balancing green space and pedestrian flow with the minimum parking capacity needed to meet code requirements. Thoughtful designs break up parking lots with islands, which reduce runoff temperature and enhance the appearance of a development. It is best to design multi-functional landscaping islands by depressing the grades, rather than mounding, and directing water through the islands to drop inlets. Bioretention and flow-through planters have significantly fewer maintenance issues and are more cost-effective than sand filters for the same filtration effects. Plus these alternatives have the added benefit of creating habitat and shade.

Because the main treatment process of these systems is filtration through the media and uptake, areas with poorly-draining soils can be designed to include underdrains to ensure that the media does not remain saturated for too long. Even if the depressed islands are not designed as formal bioretention basins, the plants in the landscape areas will use the water and filter out sediment before discharging to the drainage system. Irrigation demands and storm drain system costs will be reduced by incorporating these design features, providing a low-maintenance option that is highly beneficial to water quality downstream.



Develop a stormwater concept plan to quantify the impact of layout, materials, and management design choices.

Timmons Group used this approach on a large parking lot job in Spotsylvania County, Va., and saved roughly \$65,000 in infrastructure costs. The civil engineers worked closely with landscape architects to achieve a successful project. Together they were able to replicate the initial abstraction volume in vegetated swales located between every other parking bay, even though soils in this area of Virginia are not conducive to high rates of infiltration. The team specified domed inlets to avoid clogging and explained to the owner that part of the water-quality function of the islands is pre-treatment, meaning that trash may accumulate in them as well. These low-impact development features eliminated the need for a downstream stormwater management pond as well.

Permeable vs. impermeable

Studies show that water quality within a watershed degrades significantly as the percentage of impervious surfaces within that watershed increases. As civil engineers, we must balance the need to meet code and the owners program, and minimize the impervious surfaces. Civil engineers should constantly ask, “Does this area really need to be paved and, if so, how does it need to be paved?”

Sustainable solutions are plentiful. On redevelopment projects, the civil engineer can opt to pulverize old pavements in place to use as subgrade for the new pavement section, thereby reducing project costs and environmental impact while also contributing toward LEED materials and resources credits. In other cases, alternative paving materials, such as pervious concrete or asphalt and open grid grass or gravel systems, can decrease runoff rates, volumes, temperature, and velocities. If the soils below the permeable pavement are well drained, they can provide an additional infiltration function,

benefiting water quality. It should be noted, however, that these options do tend to cost more than asphalt lots and also require regular maintenance; we typically see a minimum increase of 15 percent for installation costs, while the increase in cost of materials usually depends on the type of section designed.



(Left) Green roofs, such as this one at 1050 K Street, can help mitigate the impact of development by detaining small storms and reducing heat island effects. (Right) Pervious pavements can reduce runoff rates, volumes, temperatures, and velocities. Balance installation costs and maintenance with reduced runoff curve numbers and infrastructure costs.

Alternative pavement sections are appropriate for low-traffic areas, such as parking stalls or fire lanes, and it is best not to drain adjacent slopes or islands across them to minimize clogging. It is important to weigh the difference between the cost of the alternative sections and the decrease in storm system and stormwater management costs.

One of Timmons Group's redevelopment projects in Richmond, Va., serves as a local demonstration area for alternative materials selection. The architect-owner chose to retrofit one of the existing buildings as a parking garage for their employees and further requested a small surface lot using various styles of pervious pavements for visitors. We added a large green area to the site, a small green roof section, and designed pervious concrete and permeable pavers in the parking stalls and plaza. The increased green spaces alone reduce runoff volumes by more than 20 percent, and the combination of bioretention and permeable pavements contains the entire one-year storm. In addition, the choice of materials significantly reduces stormwater runoff to a combined sewer system; the project is anticipating LEED Gold certification.

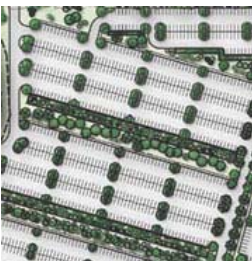
Stormwater reuse

Once the runoff is minimized by site layout and materials techniques, we can evaluate the benefits of harvesting rainwater for reuse. Surface storage is the most cost-effective containment; however, aesthetic and biological issues often arise because of the constantly fluctuating water levels. Underground storage, which costs \$3 to \$8 per cubic foot, allows for rainwater harvesting without infringing upon a site's developable area; however, adequate pre-treatment is critical to minimize the potential for odors and frequent maintenance concerns. The cost-benefit analysis for rainwater harvesting has a payback period based on the cost of water in the project region, as well as the use for which it is collected, e.g. irrigation, flushing, or potable purposes.

Another Timmons Group project, an 11-story LEED Gold certified office building in Washington D.C., is the perfect example of the impact of integrated design decisions. On the roof, an entertainment terrace of permeable pavers features two levels of green roof with media volumes sufficient to contain up to the two-year storm. A 5,000-gallon cistern in the basement of the parking garage collects both the condensate water and runoff from the plaza adjacent to the building to feed the drip irrigation system. The cistern also supplies a water feature that flows intermittently through raised bioretention planters in the plaza throughout the day. The underdrains and overflow drains of the bioretention planters lead back to the cistern and contain an overflow bypass that connects to the public storm drain system for storm events greater than the 10-year flows. The cost of these integrated design elements was only 3 percent greater than what would have been required to meet code; however, the benefits to the downstream systems are invaluable.

Erosion control

Erosion control is probably the least glamorous discipline with the greatest impact to water quality. Although it is not permanent, it is critical to the health of all downstream systems. If streams are impaired during the construction process, then post-construction water quality measures are important. One of the best services a civil engineer can provide is a thorough, practical, well-designed erosion control plan.



Multi-functional landscaping areas collect and manage water, reduce heat island effects, and improve parking lot aesthetics.

Conclusion

Although civil engineers are rarely the ones choosing which sites to develop, we must help our clients, owners, and developers make informed decisions regarding the environmental impacts of development. Each site is inherently different; there is no magic bullet for green design. It is important to evaluate which of our tools will work best for a given site: consider soils, hydrology, grades, cost, and layout, but also environmental benefits, aesthetics, and function. For civil engineers to integrate seamlessly into the green building movement, we must all abandon the idea that each discipline is distinct and independent; we must rethink our design process to build a more comprehensive and collaborative vision.

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