Small Business Innovation Research

SBIR SuccessSTORY

Mini-Roundabout

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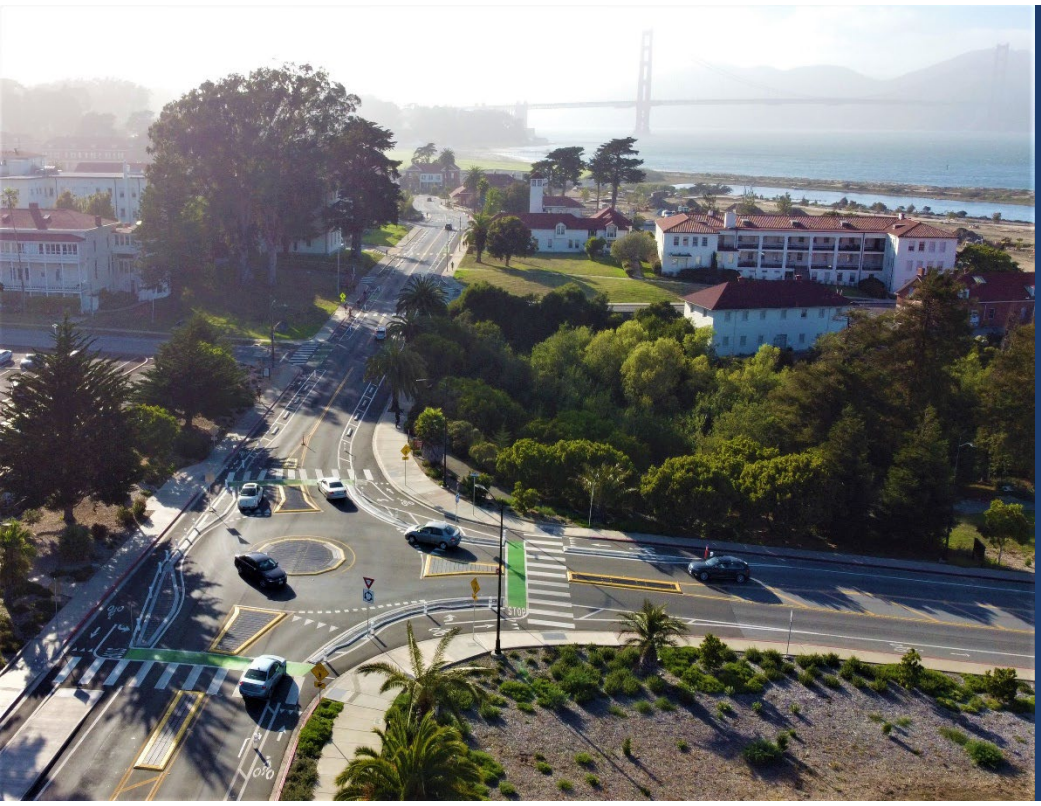


Congestion and safety at smaller but critical intersections using the modern roundabout (MRB) design principles are common problems today. The **mini-roundabout** was developed and has been deployed at hundreds of intersections across the United States to address such problems!

Figure 1. Photograph. Mini-roundabout bird's eye view.

The Short History of Roundabouts

The history of the roundabout is relatively recent and short. Its origins are based in Europe at the beginning of the 20th century, and it has only been implemented in the United States since the early 1990s. Originally designed to be an island for pedestrians, the MRB—as it was later coined—has proven to have safety and economic benefits in its evolution of use and design.

A roundabout is essentially a circular intersection. It guides drivers in a counterclockwise route around a circular center. Drivers are forced to slow down and are required to yield to vehicles already in the roundabout. Modern implementations can operate with no lighted signals or street signs in the roundabout, which helps with the continuous flow of traffic. However, when traffic demand exceeds a variable traffic volume limit, a signal can be used to alternate the right-of-way access. Roundabouts are typically installed to improve safety and traffic flow by forcing vehicles to reduce their speed as they approach the intersection. Compared with an all-way stop-control (AWSC) intersection, roundabouts can double the capacity to alleviate congestion. Because of this feature, roundabouts are suitable for intersections that have a high crash rate or overwhelming traffic delays.

A Modern Solution to a Safety Problem

What are mini-roundabouts, and why are they an advantage? Mini-roundabouts serve as small-scale versions of the MRB traffic control system that directs vehicles circularly through an intersection. Regular MRBs have nontraversable central islands, and their footprint typically requires an inscribed circular diameter of approximately 100 ft or larger. To enable large vehicles to pass through the roundabouts, truck aprons may be deployed on the edge of central islands, on shoulder corners, or on both. There are also many heavily traveled two-lane minor arterial roads on which the typical traffic control device is either a two-way stop-control (TWSC) or AWSC. The main problem at TWSC intersections is safety: During peak hours, vehicles from the minor approaches have difficulty finding a safe gap to enter the intersection. It is even more dangerous for pedestrians and bicyclists trying to cross a major road. At AWSC intersections, which are used where two minor arterial roads meet, the main problem is congestion. Congestion at such locations can block traffic on many roads, thereby feeding traffic to the two minor arterial roads.

Frank Blackmore, a U.K. traffic engineer who also invented the MRB concept, conceived the mini-roundabout in 1969. Blackmore invented the mini-roundabout to solve congestion and safety problems at smaller, but critical, intersections by using the MRB design principles. In the United States, there are currently hundreds of mini-roundabouts deployed at intersections to address these problems. To implement the MRB design principle at small intersections that serve predominately passenger cars (with less than 3 percent of the traffic being large vehicles), one logical compromise is to make the central island traversable. This design allows for occasional use by large vehicles that cannot navigate tight turns with a small radius, while making its edge high enough to discourage small vehicles from mounting the central island. A traversable central island is a distinctive feature of the mini-roundabout design, enabling it to be installed at smaller intersections where traditional MRBs cannot fit.

Source: FHWA.

Figure 2. Photograph. Mini-roundabout street-level view.

Given the success and benefits of mini-roundabouts, the Federal Highway Administration (FHWA) wanted to investigate whether there were opportunities to improve their design, functionality, and processes. With investment from FHWA through phase I, II, and IIB Small Business Innovation Research (SBIR) awards, ZKxKZ, LLC, developed a design that provides low-cost, easily installed mini-roundabouts made from recycled plastic. This low-cost, recycled technology is effective in reducing carbon footprints and is economically responsible!

Low-Cost Innovation Using Recycled Materials

The conventional methods of constructing roundabouts involve cutting the pavement and filling it with reinforced concrete. However, the modular mini-roundabouts that ZKxKZ developed can be installed and anchored directly onto existing pavement that is in good condition. According to ZKxKZ's website, "An MRB differs from more familiar large traffic circles in one significant way. Large trucks and buses making turns in a small-diameter MRB must drive over its central circle and splitter islands to navigate the turn. ZKxKZ has developed a low-cost recycled plastic MRB system designed to significantly reduce the time required for installation. The modular components of the system allow a damaged section to be replaced in minutes with a socket wrench."(1)

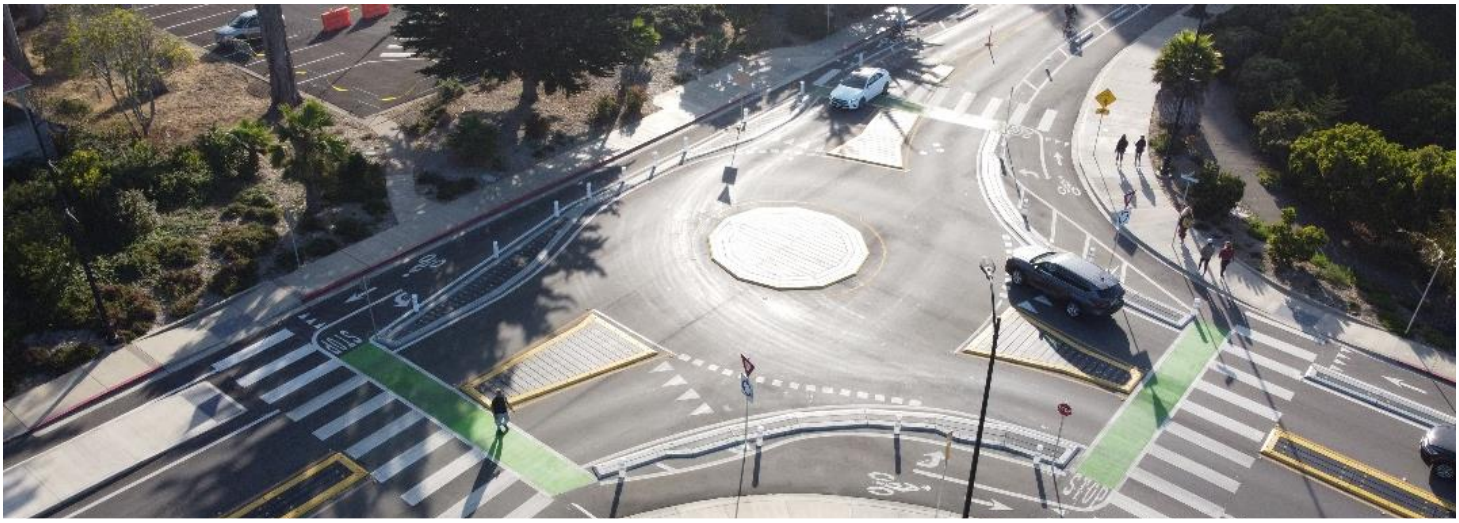
ZKxKZ uses a polyethylene-based composite to take a completely different approach to mini-roundabouts—and potentially other infrastructure installations as well. The material, which is used for railroad ties, is known to be both strong and durable while offering the opportunity to design and precut pieces for assembly at the installation site. Using computer-aided design, ZKxKZ engineers take measurements from a geometric design for an installation site and translate them into a modular mini-roundabout design, which is made up of hundreds of parts that fit together like a jigsaw puzzle. Using this approach, precut boards can be delivered onsite, ready to be installed. To complete the installation, the precut plastic boards are lined up on the pavement according to the plan's geometric design. The installer then drills through each piece's precut holes and into the pavement, fills the holes with cement, and secures the boards by using anchors. This process simplifies the labor and, more importantly, does not require the complete closure of the intersection, thereby minimizing the effect on the traveling public.

> "[A] low-cost recycled plastic MRB system designed to greatly reduce the time required for installation… allow a damaged section to be replaced in minutes with a socket wrench."
>
> *—ZKxKZ, LLC*

Federal Funding Fosters New Infrastructure Improvements

Through the FHWA's SBIR award investments, ZKxKZ collaborated with both Georgia Department of Transportation (GDOT) and Virginia DOT (VDOT) for initial sites in Jackson, GA, and Annandale, VA. Because the mini-roundabouts are easy to install, modify, or remove, these sites also provided a convenient method for testing and evaluating the effects at intersections. For example, the Jackson, GA, site required postinstallation design changes due to the entry speeds into the roundabout being deemed higher than desired. Small modifications to the center islands and splitter island shapes were implemented to change driver behavior.

The major benefits of these recycled plastic mini-roundabouts are obvious: They can fit into existing intersection rights-of-way, they are inexpensive because they are smaller, and they use recycled material. But the benefits do not stop there! As the system has undergone development and improvement, it has shown its potential to be used in other road features. ZKxKZ currently has 10 commercial installations, including one site in Silver Spring, MD.



Source: ZKxKZ, LLC.

Figure 3. Photograph. Mini-roundabout.

The system is a spinoff for a modular roadway system where the road did not have a sidewalk. It was adopted for use as a lane divider for safety enhancements to segregate the lane for pedestrians, along with the creation of a bike lane. The technology's simple installation techniques and adaptable design characteristics have made it an effective solution with the potential to address a variety of other traffic issues as development is furthered.

The success of these installations and the potential for other future infrastructure-related improvements, such as channeling curbs and bike lane dividers, led FHWA to invest further into the development of the system through the SBIR phase IIB award. Some of those developments include load transfer mechanisms to distribute vehicle impact loads to neighboring boards and anchors. To help redistribute impact loads, the boards, which are held down with anchors, now include dog bone-shaped flexible connectors to connect the plastic boards. When the external plastic boards are hit by vehicles, the impact force is partially resisted by the anchors holding down the boards and partially transferred to internal boards and their attached anchors through the "dog bone" connectors to reduce the potential of localized material failures.

This innovative SBIR-funded technology has led VDOT to create and install more mini-roundabouts since the completion of phase II in Richmond, VA, with three more sites being planned. The success of these installations has also led to the Department of Defense adding $750,000 to the U.S. DOT contract for defense-specific systems development, furthering the SBIR program's mission to help small businesses participate in Federal research and development, while also fostering the commercialization potential of this novel technology.

References

1. ZKxKZ, LLC. 2022. "Mini-Roundabouts" (web page). http://zkxkz.com/index.php/mini-roundabouts/, last accessed May 18, 2022.

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