Air Quality and Modern Roundabouts

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Request for Report
Roundabouts are increasingly being used to replace a variety of types of intersections, usually for traffic flow management or to improve safety. Improvements in air quality and reductions in emissions may also be taken into consideration by transportation officials as they attempt to maximize roundabout benefits. We were asked to review studies that address the air quality benefits of roundabouts.

Summary
Modern, single lane roundabouts, as opposed to older, multi-lane traffic circles, are a relatively recent innovation, especially in the United States. Although most of the research that has been conducted on roundabouts has related to safety, we found several studies that specifically focused on air quality impacts.

The studies we identified point to potential beneficial effects on air quality when standard intersections are replaced by roundabouts. However, the benefits depend on many factors such as traffic volume, number of arms entering the roundabout, and the type of intersection the roundabout replaces. In some situations, emissions were found to increase after roundabouts replace standard intersections. Research into air quality at roundabouts includes actual before-and-after measurements of specific pollutants and simulations of expected emission reductions based on traffic flow. Several methods were used to determine the level of emissions.

Before-and-after measurements

This Swedish study found that emissions actually increased at some new roundabouts, but not as much as they decreased at others. The abstract:

“Intersections on arterials were rebuilt as small roundabouts in a Swedish town with the goal of improving traffic safety. One of the intersections was originally signalized while others were yield-regulated. To measure CO and NOx emissions and fuel consumption before and after the roundabouts were installed, random cars were selected and followed with an instrument-equipped vehicle that tried to imitate the followed car's driving pattern as closely as possible. Results of the study found that CO emissions decreased by 29%, NOx emissions decreased by 21% and
fuel consumption by 28% at the roundabout that replaced the signalized junction. At roundabouts replacing yield regulated junctions, CO emissions increased by 4%, NOx emissions by 6% and fuel consumption by 3%. These results indicated that the larger reductions in emissions and fuel consumption at one former signalized intersection can compensate for the increase produced by several yield-regulated junctions rebuilt as roundabouts.”


Congestion levels at the approaches to the roundabout may also increase emissions, as researchers in Lisbon, Portugal and Raleigh, North Carolina observed. When the approaches to a roundabout have a heavy traffic volume, cars may experience more stop and go cycles than at a standard intersection, causing an increase in emissions.

From the abstract: “The approach attempts to explain the interaction between roundabout system operational variables (entry volume, conflicting volume and roundabout geometry) and the resulting traffic performance and vehicle emissions…Using the congestion-appropriate speed profiles of vehicles on roundabout approaches, the emissions calculation methodology is used to quantify the relationships between vehicle dynamics and emissions.”


This Swiss study addresses the number of arms entering the roundabout, traffic density and composition, dimensions of the roundabout, presence or absence of pedestrian crosswalks, and the ultimate direction of most of the traffic; that is, whether most of the traffic is proceeding straight through, turning left, etc. A description of the test vehicle, conditions at the tested intersections, charts, and references are included. From page 3 of the study:

“The evaluation of the results showed no unambiguous trend in the effects of the conversions from crossing to roundabout. The effects of conversion of a crossing to a roundabout on crossing times, fuel consumption, emissions of pollutants etc. depended very much on local factors such as the amount of traffic, frequency of interruption of traffic flow by pedestrians, the ratio of traffic density on the different branches etc. Since the traffic density varies greatly during the day at most roundabouts, a roundabout can have a favourable effect at certain times of day contrasting with an unfavourable effect on the variables mentioned at other times.

“The effects are favourable where a light-controlled crossing is replaced by a roundabout. When a roundabout replaces a crossing without light signals the effects on fuel consumption and harmful emissions are often unfavourable, since the roundabout disturbs previously uninterrupted travel.”

Simulations

These studies use computer simulation to estimate emissions before and after conversion from a standard intersection to a roundabout. Traffic flow data was analyzed using Signalized and Unsignalized Intersection Design and Research Aid (SIDRA).


Six sites in Kansas and Nevada were chosen for the study. In each, a Stop controlled intersection was replaced by a modern roundabout. Traffic flow data was extracted from videotapes of each intersection. The simulation analysis indicated that emissions should be reduced at each of the intersections in the study. Tables include traffic volume with percentage of left turns at each site, and emission levels before and after conversion. From the abstract:

“All the MOEs [measures of effectiveness] were statistically compared to determine which intersection control performed better. After comparing all the MOEs at all locations for the before and after traffic volumes, it was found that the modern roundabout performed better than the existing intersection control (i.e., stop signs) in cutting down vehicular emissions thereby creating a positive impact on the environment. The research concludes that a modern
roundabout can be used, as a viable alternative to cut down vehicular emissions and thereby making intersections more environment friendly. “

This paper includes estimates of emissions reductions along with estimated motor fuel savings, and discusses target reductions in Kyoto protocol terms. From the executive summary:

“Modeling and empirical studies of busy highway intersections document a substantial short term benefit from installing modern roundabouts. Motor fuel consumption and associated air pollutants are reduced, and the primary global warming gas (GHG), CO₂, is significantly cut.”