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Abstract

Local agencies and contractors are facing unanticipated challenges during the construction phase of modern roundabouts. This paper draws upon the experience and insight of local contractors and agencies that have recently built modern roundabouts in the North Texas area. It outlines the major challenges they have encountered in an effort to help others identify potential issues early in the design phase and plan accordingly. The collected information and challenges include:

- Unintended re-mobilization
- Tear-out of pavement/curbs
- Inconsistent paving details
- Optimized construction timeline versus worker safety

Un-intended re-mobilization

At existing intersections, several factors influence the ability to reduce the number of construction phases while maintaining existing traffic or providing partial traffic operations with detours. It is key for the design engineer to develop traffic control plans and conduct constructability reviews early on so the optimum handling of traffic is addressed within the construction documents. The plans should adequately address re-mobilization efforts due to leave-outs of splitter island curb, truck apron curb, pavers or outside circulatory curb resulting from how traffic is routed during the construction process. By failing to communicate re-mobilization efforts in the construction documents, contractors and local agencies may be forced to provide additional time and money to the construction of a roundabout.

Tear-out of pavement/curbs

As subsequent phases of traffic control plans are developed, the design engineer should compare each phase's routing of traffic to previously placed limits of splitter island, truck apron, and outer circulatory curb. For example, in order to convey phase three or phase four traffic through an existing intersection, portions, if not all, of splitter island and truck apron curbing may require that curb is not constructed within phase one or phase two. Evaluating pavement and curb elements built versus subsequent phases of traffic routing can minimize the contractor's need to remove previously placed pavement/curbs, ultimately saving the contractor and the local agency time and money.

Inconsistent paving details

Constructability reviews must cover paving details that specify differing depths of pavement to be placed within the roadway pavement section versus the splitter island area or truck apron. Slight changes to the depth of paving sections over short distances can make it hard for the contractor to compact the subgrade material to meet specifications while simultaneously providing the dimensions shown within the engineer's construction drawings. Subgrade preparation methods should also be analyzed to account for limited work zone areas, schedule, and cost.

Optimized construction timeline versus worker safety

While decreased phases of construction may shorten the schedule, several example projects show that when provided an additional construction phase, worker safety and the work zones provided substantially increase. Balancing the construction timeline and worker safety needs to be proactively discussed amongst design engineers and reviewing agencies to ensure safety is not sacrificed for expeditious construction.

Abstract

In summary, modern roundabouts are quickly becoming the preferential choice for intersection control, but many contractors and agencies are facing unanticipated challenges due to a lack of construction experience. Common challenges that local contractors and agencies are facing are highlighted here-in. By sharing common construction challenges, we can minimize their occurrence on other projects and help each other anticipate issues and plan accordingly.

Recent Challenges with Modern Roundabout Construction
White Paper on Identifying Potential Roundabout Construction Issues

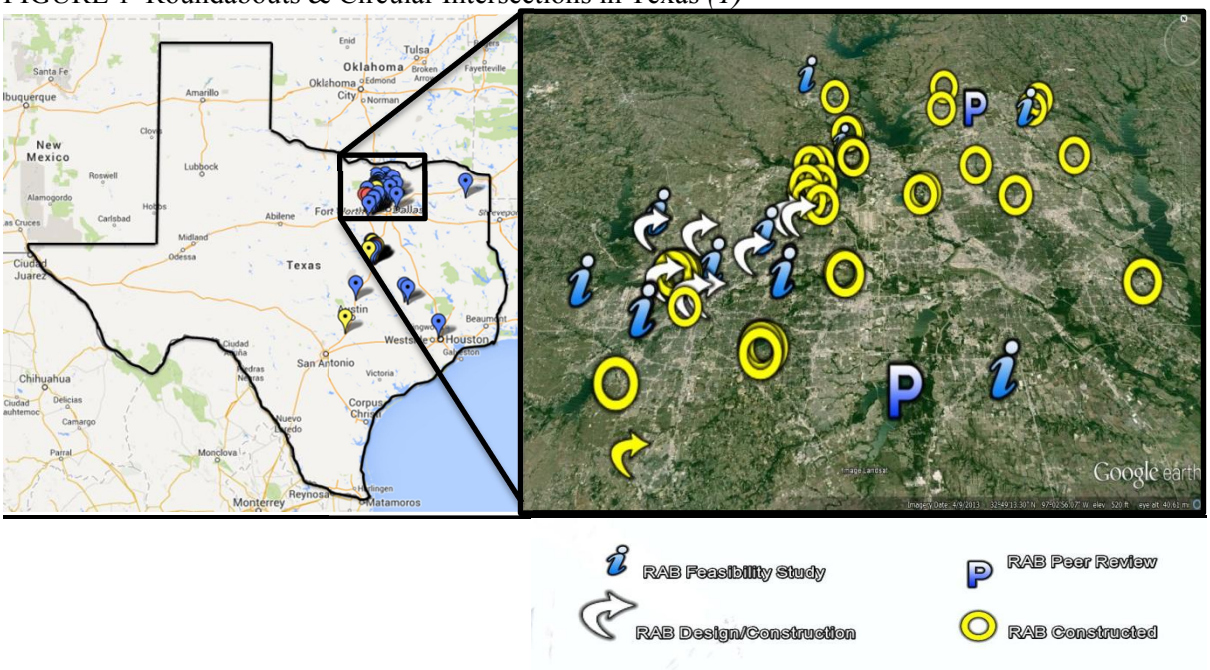
Local agencies and contractors within the North Texas area are facing unanticipated challenges during the construction phase of modern roundabouts. Modern roundabout construction within the Dallas-Fort Worth (DFW) area could be considered to be in its infancy stages compared to several other areas of the United States, which poses a challenge for many in the roundabout community - from design engineers to inspectors to contractors. Figure 1 shows an approximate current inventory of existing circular intersections in the DFW area, with most of these circular intersections being modern roundabouts constructed within the past five (5) years. As local government agencies (LGAs) and developers gain interest in this type of intersection control, experience designing and constructing roundabouts in the area will undoubtedly increase. Until that time the area will continue to see first-time roundabout contractors being awarded modern roundabout projects and possibly encountering unanticipated construction-related issues.

In the fall of 2013 several contractors in the DFW area were approached to provide a bid proposal for a privately-funded roundabout at an existing four-leg intersection. One contractor, who was recommended by a fellow design consultant because of the contractor's construction experience on another local roundabout built in 2012-2013, declined to provide a bid. This contractor made it known they were no longer pursuing roundabout projects given the issues that arose with the previously constructed roundabout. Further questioning of the contractor lead to several issues being identified as to why the contractor had reservations about future roundabout construction services. Similar concerns were also echoed by other local contractors and inspectors.

It is in the roundabout community's best interest to minimize construction related issues for contractors who otherwise may decline to bid on future area projects. Therefore, this paper highlights four areas of concern arising out of discussions with the contractors. These include:

- Unintended re-mobilization
- Tear-out of pavement/curbs
- Inconsistent paving details
- Optimized construction timeline versus worker safety

FIGURE 1 Roundabouts & Circular Intersections in Texas *(1)*



This paper discusses the four concerns noted above and serves as a mechanism for spreading awareness about potential roundabout construction issues.

UN-INTENDED RE-MOBILIZATION

At existing intersections where a roundabout is to be retrofitted, several factors influence the ability to reduce the number of construction phases while maintaining existing traffic or providing partial traffic operations with detours. In order for the contractor to avoid un-intended re-mobilization efforts it is highly important for the design engineer to develop traffic control plans and conduct constructability reviews throughout the development of the project's construction documents so additional re-mobilization efforts to complete the roundabout may be addressed. By communicating re-mobilization efforts in the construction documents, whether it is via notes or separate pay items, LGAs and contractors may avoid a later dispute about scope of work, change orders, and a subsequent delay to the project's construction.

Two issues related to re-mobilization during partial closures of traffic through the work zone area include:

1. Paver installation - A contractor will be quick to reserve paver placement towards the end of the construction schedule versus segmented installation. This allows the contractor to mobilize a paver crew at one time instead of multiple times throughout the project to potentially install pavers within the truck apron, splitter island and/or crosswalk area. If an owner has a preference that drives segmented installation of pavers on the project, the contractor will need to be made aware of this process prior to bidding to account for the additional mobilization efforts. Transparency in the traffic control plans of what is to be constructed per phase and what is not, additional notation, and general notes can assist the contractor to better understand the engineer's and owner's intention regarding installation of pavers, if pavers are to be utilized.

2. Doweled-on curb - Phased construction of the roundabout may result in certain segments of curb being deferred until the end of the project. Delaying construction of segments of curb can help facilitate the shifting of traffic within various phases of construction while the adjoining pavement section is built. This includes the central island curb as well as splitter island curb and curbing on the outermost portions of the circulatory roadway. Doweled-on curb sections should be accounted for in the design plans and the contractor's bid proposal, when possible, for the increased mobilization efforts of doweled-on curb versus monolithic or integrally-placed curb to be appropriately planned for during bidding and construction.

TEAR-OUT OF PAVEMENT/CURBS

As subsequent phases of traffic control plans are developed, the design engineer should compare each phase's routing of traffic to previously placed limits of splitter island, truck apron, and outer circulatory curb as well as limits of permanent pavement. For example, in order to convey traffic within a third or fourth phase of construction through an intersection, portions, if not all, of splitter island and truck apron curb may require that such curb is not constructed within phase one or phase two. Evaluating pavement and curb elements built versus subsequent phases of traffic routing can minimize the contractor's need to remove previously placed pavement/curbs, ultimately saving the LGA and the contractor time and money.

While some jurisdictions have traffic control standard details that are commonly applied to routine temporary work zone conditions, the reconstruction of existing intersections under full or partial traffic conditions warrants the need for specific traffic control plans to be developed for each construction phase. By analyzing and evaluating traffic routing and allowable boundaries of the roundabout that are able to be

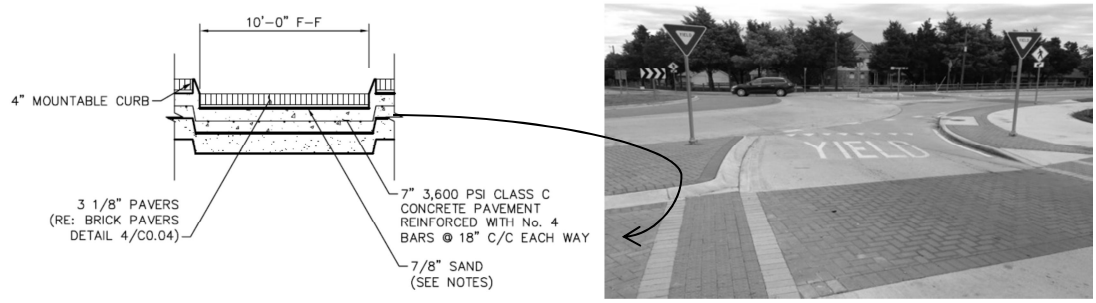
constructed within each phase, situations of tear-out/removal and reconstruction of pavement and curbs may ultimately be avoided.

INCONSISTENT PAVING DETAILS

Constructability reviews should cover paving details that specify differing depths of surface pavement, paver installation, base material, and subgrade as they relate to the splitter island area, truck apron, and/or crosswalk. Attention should be given to the pavement section and related stabilization methods. As the North Texas area continues to see an increase in modern roundabout construction, roundabout-related details will undoubtedly evolve and create a scenario for contractors to avoid inconsistencies with the associated paving details. Three aspects of roundabout paving details to consider are listed below. Local contractor feedback focuses on these details that can impact constructability and pricing.

1. Pavement Section Details - During the design process time may be spent focusing on intricate details of stepped up and stepped down pavement sections where the subbase and subgrade portion of the pavement section mirrors overlying pavement zones. These slight changes to the vertical depth and geometries of subbase and subgrade material over short horizontal distances are nearly impossible to construct. Figure 2 shows an example of stepped construction at a crosswalk location. Inappropriate details that are hard to construct lead to a waste factor where a less-experienced contractor may lose money as he may not have accounted for the additional waste and haul-off in his bid. Change orders may ensue and create friction between the contractor and the owner. Therefore, these slight changes to the depth of paving sections over short distances should be avoided. These scenarios can make it difficult for the contractor to compact the subgrade material to meet specifications while simultaneously providing the dimensions shown within the engineer's construction drawings.

FIGURE 2 - crosswalk



2. Paver Installation Details - Brick or concrete paver details and installation have been found to be problematic to accessibility issues. Over time pavers may have the tendency to shift or be jarred and pop out of their pocketed placement altogether. The specifications for installation of pavers can also have a slight impact on the timeline of construction due to a typical underlayment phase, stabilized sand placement, and the remaining installation process for the individual pavers. Many recent local roundabout projects have abandoned the use of pavers and instead are constructing crosswalks and other contrast paved surface areas with stamped and colored concrete/asphalt. Owners should evaluate the use of pavers within roundabout projects and weigh the option of stamped and colored concrete or stamped and colored asphalt pavement, depending on the type of surface pavement being constructed.

3. Subgrade Preparation - There are two preferred methods for subgrade preparation.

A. Flexible base – This type of roadway foundation is based on a gradation of aggregates, with requirements for liquid limit, plasticity index, and compressive strengths for the product that is specified. Crushed stone, crushed or uncrushed gravel, or crushed concrete are the most common

materials for flexible base. This method is thought to save time, however, it may require additional excavation in order to remove existing material in the field that would conflict with the horizontal and vertical limits of placement of the flexible base. Due to potential limited access for equipment and a limited work zone area it can also be difficult to achieve optimum compaction. Waste material, as mentioned previously, is another cost overrun factor with the installation of a specified flexible base. Excavation quantities should be provided in the plans when flexible base is used as a subgrade option.

B. Lime/Cement Stabilized - This method reduces the contractor excavation effort, however, it also presents challenges due to the potential limited work zone areas, high cost of mobilizations when a project is phased, and compaction problems similar to the flexible base method. Stabilized subgrade methods and options should be analyzed early in the design process to ensure the adequate method is applied for each individual roundabout location.

Contractor feedback indicates a possible preference for an alternate, or third subgrade preparation method, that utilizes a thickened concrete/asphalt pavement section as the most efficient process. By utilizing the existing subgrade material, after compacting to meet project specifications, a thickened concrete or asphalt pavement section can limit the amount and type of equipment needed within the work zone and decrease the construction timeline. Costs may be initially higher based on the increase in depth of the concrete/asphalt pavement, however, longevity of the pavement section and consistency in the rideability of the pavement are likely to be increased.

OPTIMIZED CONSTRUCTION TIMELINE VERSUS WORKER SAFETY

While decreasing the number of phases of construction may shorten a project's schedule, it can also have a resulting negative impact on worker safety and available staging and work zone area that can be provided. This is the most challenging issue for successful roundabout construction. Regardless of the amount of barricades, signage or advanced warning signs the traveling public almost always seems to view work zones as an inconvenience. The angst felt by this inconvenience is often taken out on the construction worker by the traveling public. Daily diligence by the contractor and inspector is the only way to keep worker safety at its optimum without total closure of the work zone area to traffic.

With a majority of the local area roundabouts being constructed at existing intersections along minor and sometimes principal arterials, providing as much construction staging area within the phasing of the project becomes a catalyst for the efficient, safe, and highest quality construction. Balancing the construction timeline and worker safety needs to be proactively discussed amongst design engineers and reviewing agencies to ensure safety is not sacrificed for expeditious construction.

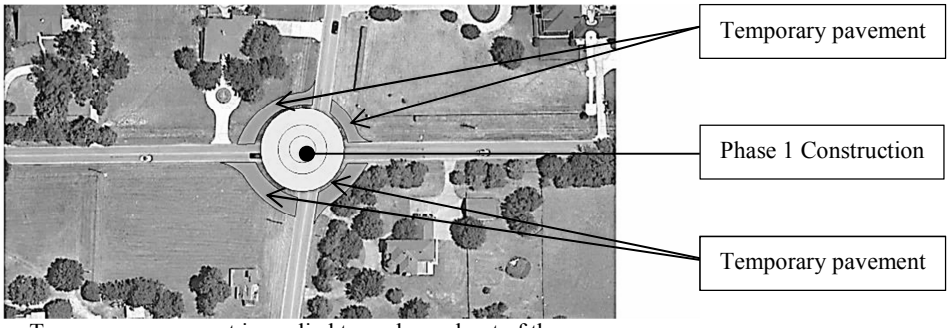
The two most common methods for reconstructing existing intersections are 1) full traffic closure and 2) partial traffic closure with temporary pavement. In most communities it can be nearly impossible to provide a full closure for construction due to limited detour options, public backlash, and political pressure from citizens to maintain their pre-construction traffic routes even with increased delay through the construction work area. Where full closures are possible with viable alternate routes, the closure of the intersection is by far the optimum construction process. Construction duration can be reduced by approximately 30-40 percent with contractor costs also being potentially reduced by 20-30% (Robert Farrow, unpublished data). In this scenario worker safety is optimized, re-mobilization efforts for paving crews are avoided, the use of temporary pavements can be eliminated, and clean consistent pavement and associated joint patterns are most easily obtained.

In the likely scenario that a full closure is not an option for roundabout construction at an existing intersection, partial closure becomes the common construction practice in rehabilitation roundabout construction. Within the partial closure method there are two sub-methods of lane closure and construction sequence for phased roundabout construction, as noted below:

1. Build From the Center Outward - This sub-method of partial closure detours traffic around the work zone area while the roundabout is constructed by completing the central island area and circulatory, followed by the phase construction of each leg of the roundabout. This sub-method introduces the traveling public to the circular traffic flow pattern during construction and can provide for an uninterrupted inner traffic circle construction operation. The downfall of this option is the multiple phases required to connect approach and departure legs to the circulatory roadway. This sub-method is limited to larger possible work zone areas (larger right-of-ways) that can provide the footprint for temporary pavement routes around the inscribed circle diameter (ICD) of the roundabout. No substantial time savings have been recorded using this sub-method over the second sub-method to be discussed next (Robert Farrow, unpublished data).

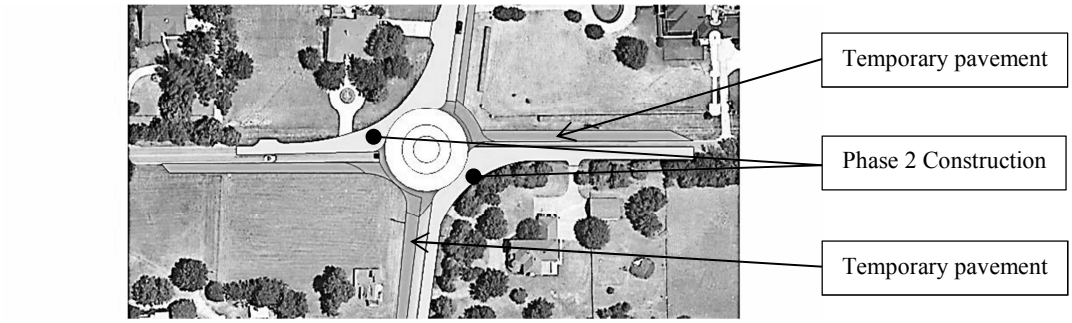
EXHIBIT 1 – Example of a local 4-leg intersection being converted to a SLR via sub-method 1

Phase 1 Construction



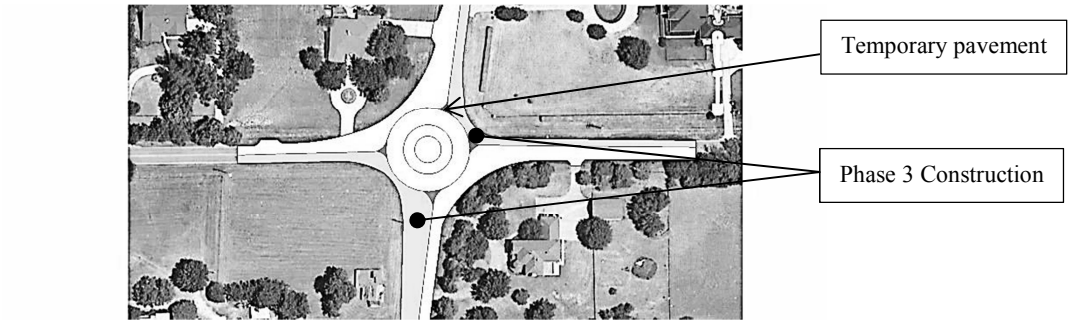
Temporary pavement is applied to each quadrant of the existing intersection around the ultimate Inscribed Circle Diameter (ICD). Traffic uses temporary pavement while the central island and circulating lanes are constructed. Intersection functions with all-way stop control during this phase.

Phase 2 Construction



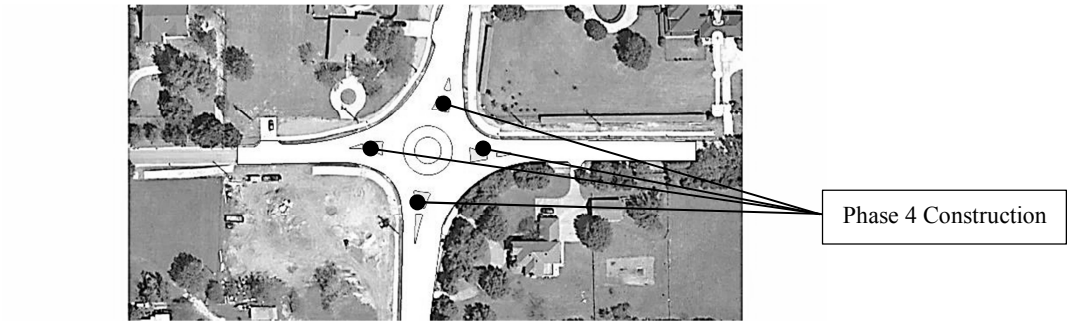
Additional temporary pavement is applied to each quadrant for two of the approach legs and two of the departure legs. Traffic on each leg uses one existing lane and one temporary pavement lane. The central island and circulatory are fully functional having been built in phase 1. This phase introduces vehicles to a counter-clockwise circulating movement.

Phase 3 Construction



Traffic on each leg uses pavement constructed during phase 2. The remainders of the proposed approach/departure legs are constructed. The intersection continues to function via use of the circulating lanes built in phase 1.

Phase 4 Construction



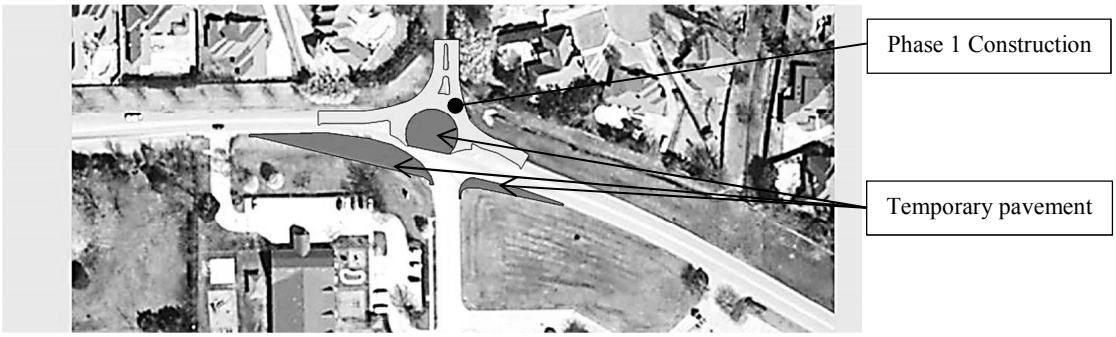
Traffic is placed within its ultimate lane configuration. The remaining splitter islands are constructed.

2. "Portion of the Pie" - This sub-method moves traffic within the work zone with the roundabout being constructed by completing quadrants of the roundabout, essentially phasing each adjacent approach and departure. Traffic moves from side to side with the central island, circulatory lanes, and splitter islands being built in three or four phases. Multiple traffic pattern modifications by the contractor may cause the traveling public angst, however, this sub-method allows for the most continuous paving operations of the phased process. The ability to construct underground utility improvements as

part of the roundabout project may also be impacted in this sub-method, unless those improvements can be completed prior to the actual start of roundabout-related improvements.

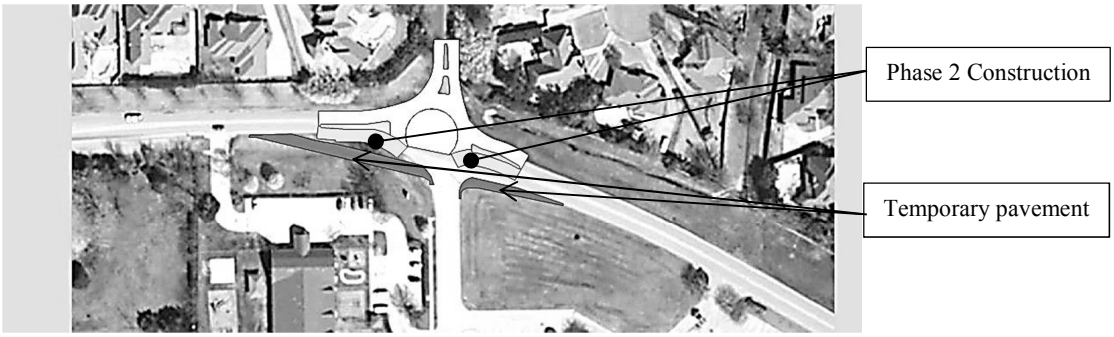
EXHIBIT 2 – Example of a local 4-leg intersection being converted to a SLR via sub-method 2

Phase 1 Construction



Temporary pavement is applied on the southern side of the intersection with eastbound and westbound traffic being shifted to the south. The northern leg is closed during Phase 1 allowing the construction of nearly half of the overall roundabout.

Phase 2 Construction

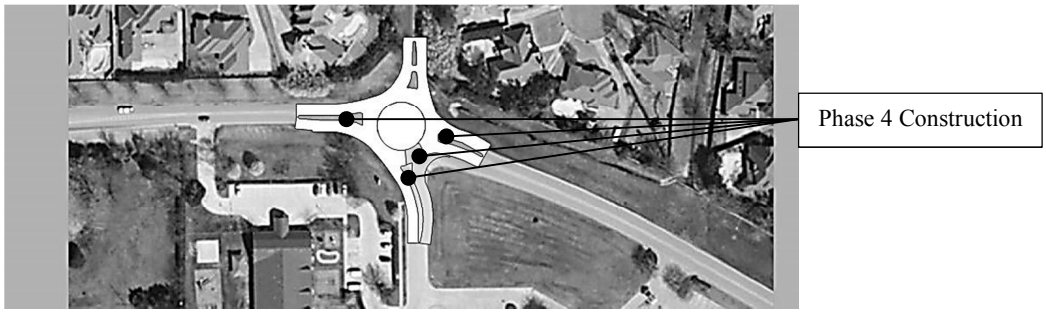


Westbound traffic uses the pavement constructed in phase 1. Eastbound traffic continues to utilize temporary pavement. The eastbound entry and departure leg is constructed in phase 2. Intersection operates under full access. The central island area and splitter islands are built flush with adjacent pavement (no mountable curb, truck apron or central island landscaping is applied until the final phase of construction).

Phase 3 Construction

Eastbound traffic is shifted back to the north and utilizes the splitter island areas and central island areas of the roundabout. The south leg is phase constructed to accommodate the businesses with driveways south of the roundabout.

Phase 4 Construction



The south leg construction is finalized. The central island area and splitter islands are also constructed during this phase.

For both of the sub-methods mentioned here-in, there are resulting impacts on available lateral buffer areas - the distances between construction workers and the traveling public. While designers, inspectors and contractors will strive to expedite construction operations with reduced phases, it is critical to evaluate the safety and potential issues that may occur related to confined work spaces for the partial closure scenario.

In summary, modern roundabouts are quickly becoming the preferential choice for intersection control, but many LGAs and contractors may face unanticipated challenges due to a lack of circular intersection construction experience. Common challenges that LGAs and local contractors may encounter are highlighted here-in. By sharing common construction challenges, we can minimize their occurrence on other projects and help in the roundabout community anticipate issues, plan accordingly and continue the positive trend of increased roundabout construction in many different states and local areas across the country.

References

1. Google Maps, 2014. *Roundabouts & Circular Intersections in Texas.* Norman Hogue, P.E. https://maps.google.com/maps/ms?vps=2&ie=UTF8&hl=en&oe=UTF8&msa=0&msid=210373909400090109857.0004ccedb2230492a7c7a. Accessed Feb. 3, 2014.