Riverton Roundabout Design Project

Tuckett & Ferguson Consulting

Prepared for:
Trace Robinson
Director of Public Works
Riverton City

Prepared by:
Tuckett & Ferguson Consulting Firm
Brigham Young University

April 9, 2012

Trace Robinson
Director of Public Works
Riverton City

Dear Mr. Robinson:

We, Tuckett & Ferguson Consulting, are pleased to deliver our study on the feasibility and design of a roundabout on the intersection of Riverton Boulevard and 4150 West in Riverton, Utah. This paper represents the final concept idea, description, and explanation of our roundabout that we designed as our Senior Design Project. Enclosed you will find the collaboration of our group from the last semester.

We feel our design is plausible, feasible, and safe. It is a good solution to keep future traffic in the area moving safely and efficiently. In the report, you will find that our design includes the constraints and difficulties we encountered. We also have written briefly about future problems that might arise due to our design as well as including an alternative to our design. Lastly, after considering the problems and the alternative, we have made a recommendation based on our analysis.

If you have any questions, please feel free to contact us.

Sincerely,

Tuckett & Ferguson Consulting

Ben Tuckett Project Leader	Pete Kelly Site Planning/Traffic Analysis	Tyson Ferguson Civil 3D/Traffic Analysis
Josh Belnap Safety/Geometric Design	Rob Naylor Civil 3D/Geometric Design	

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Introduction

Project Overview

The Riverton Roundabout Project is a part of a new development and expansion that will be built within the city limits of Riverton, Utah (UT). With more attractions, shopping centers, and commercial development, there will be an increase of traffic to the area. Part of the development in the area is a proposed roundabout that will serve as an intersection between Riverton Boulevard (Blvd) and 4150 West.

Tuckett & Ferguson was created in the fall of 2011 as part of a senior design class in the Civil and Environmental Engineering program at Brigham Young University. All five members of the group had interest in transportation engineering. Tuckett & Ferguson submitted a proposal for the Riverton Roundabout Project and was awarded the project in December 2011.

Purpose and Need

In contrast with the existing economic conditions in the United States, Utah has been resisting the national trends of high unemployment and economic decay. Utah is rapidly becoming a destination for firms and companies to relocate their offices and personnel, especially along the Wasatch front. With space to accommodate this growth, Utah cities and metropolitan planning organizations (MPO) are hurriedly trying to meet the challenge.

Much like the state, Riverton City is experiencing large amounts of growth, as they also look towards the future to process this anticipated influx. Most recent estimates show that over 40,000 residents currently call Riverton home, and forecasts show that population numbers are expected to reach 100,000 people within the next 20 years.

Site Description

Located in the southern portion of Salt Lake County, Riverton City is conveniently located along Bangerter Highway and the new Mountain View Corridor, with easy access to I-15. This accessibility is just one of many reasons that Riverton City is becoming the target of both commercial and residential relocation. Current projects are largely focused on improving transportation, not only to accommodate traffic at the present time, but to accomplish the same effectiveness for future volumes. This need is considered throughout the body of this report, which is focused on the analysis and design of an intersection for an undeveloped area of Riverton City.

The area of focus is the Latter-Day Saint (LDS) Church farm located at 13400 South and 4500 West. Although the property now serves as a source for welfare produce, it will eventually be developed into a mixture of housing developments, retail outlets and office spaces. The terrain is relatively flat, with little or no presence of existing structures, obstructions, or even existing roadways. The roadways that will be constructed to enter into the site will have relatively high densities, so a design that allows high vehicle flow rates to pass through with minimal delays while maintaining safety is required.

The property in question is not owned by Riverton City, and therefore, will require the purchasing of right-of-way (ROW) from the property owners before construction begins. This places constraints on the design itself. A roundabout here is favored due to its effects on traffic flows, its unique safety benefits, and also because it is often less expensive than a signalized intersection. However, in many cases, roundabouts require that more ROW be purchased than a traditional intersection. All of these issues affect the final price of the project, as well as the overall effectiveness and safety of the feature. The roundabout designed and proposed by Tuckett

& Ferguson minimizes the amount of ROW needed while providing safety and efficient movement of the projected 2030 volumes.

Design

The initial design for the proposed roundabout was a traditional two lane roundabout. Tuckett & Ferguson decided to propose a single lane roundabout with a slip lane at each approach. This design still utilizes two approach lanes and two exit lanes at each connection. (See Figure 1: Roundabout with Slip Lanes) The benefits of this new design are: First, there are less collision points; second, there will be no weaving; last, fewer cars will enter the roundabout, making the roundabout more efficient. Critics of this design might say that drivers will be confused, but with proper signage to help guide the drivers it will be user-friendly.

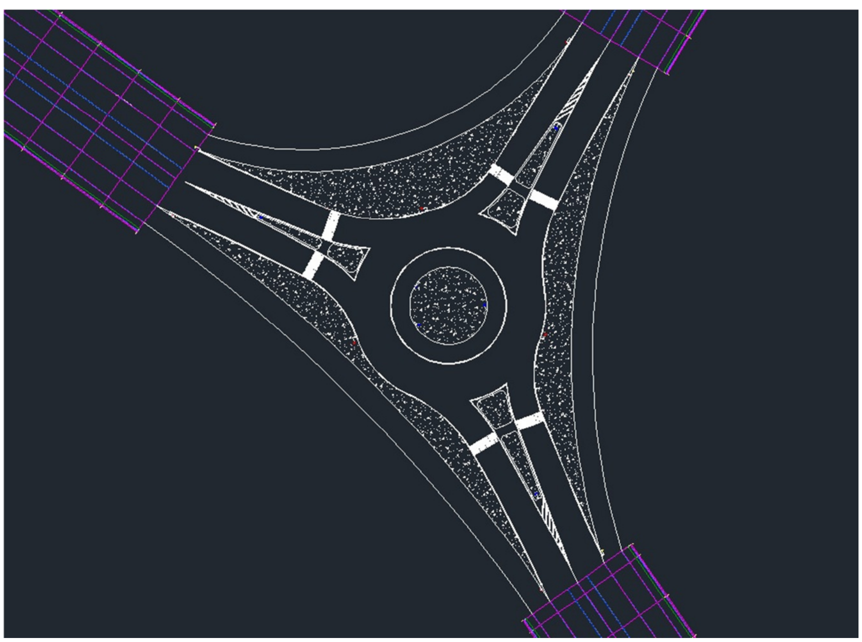


Figure 1: Roundabout with Slip Lanes

Safety

One of the major advantages of having slip lanes as part of the design is improved safety. The initial concept involved a traditional two-lane roundabout. This design, however, creates 12 possible points of conflict where vehicles cross paths and have the potential of crashing. With the addition of slip lanes, the number of conflict points decreases to only three. With less conflict points, there is a major improvement to the safety of the roundabout.

Also, an advantage for using slip lanes is that there is only one lane of cars in the roundabout. This eliminates the need to weave or change lanes within the roundabout itself. Drivers will need to determine which lane they need to be in, requiring merging and weaving to occur well before the roundabout. It should be noted that adequate signage will be provided, which will be discussed in the traffic control devices section. When vehicles approach the roundabout, drivers will only need to yield to vehicles already in the roundabout. The vehicles in the slip lanes will not enter the roundabout at all. Ultimately, with the addition of slip lanes, vehicles will not have to merge or change lanes near the roundabout.

Efficiency

The two main criteria regarding the design of this roundabout were the level of service (LOS) and right-of-way. The design had to feature enough lanes to provide at least a LOS C, but also limit the space needed to construct it. Riverton City's transportation master plan has scheduled each of the three approach roads to have two-way traffic and four lanes total. This led to the design initially being a two-lane roundabout. Tuckett & Ferguson wanted to find an innovative way to create the roundabout, so the design turned into a one-lane roundabout with slip lanes. This had a positive effect on efficiency by allowing the motorists using the slip lanes to perform their desired maneuvers without having to yield to vehicles in the roundabout.

However, motorists using the slip lanes should slow down enough to safely make the turning movement. Another advantage over the traditional two-lane roundabout is that there is no weaving in the roundabout. Weaving maneuvers cause vehicles to slow down and increases delay. The numerical data to support these assumptions will be shown in the Highway Capacity Manual (HCM) section.

Traffic Control Devices

Many drivers in the Riverton area are neither accustomed to roundabouts nor roundabouts with slip lanes. Proper signage will help these drivers navigate this particular roundabout. A combination of both pavement markings and posted signs will allow for drivers to be better prepared in any set of conditions. The markings and signs clarify the rules of the road while also facilitating through and turning movements in a manner such that drivers choose the appropriate lane when approaching. Even though markings and signs portray the same message they are both necessary in case one or the other is not viewable by a particular driver.

Signs

The sign is the driver's primary resource of information for the roundabout. The pavement markings give general instructions while the signs can be more specific. The will be a sign 250 feet before the roundabout that will warn the driver that they are approaching a roundabout (see Figure 2: Simple Roundabout Sign). Another sign will be placed 50 feet after the first to instruct them as to which lane they should be in to get to their desired turning movement. A distance of two hundred feet will provide the driver enough space to merge into the correct lane (Federal Highway Administration, 2010) . (see Figures 3-5) Another sign will be placed 150 feet before the roundabout to show the names of the possible exit streets (see Figure 6). Just as the driver approaches the roundabout there will be a yield sign on the right side and a one way sign on the inner island ensuring that drivers go counter-clockwise. These signs will make the roundabout user-friendly and very easy to operate.

Figure 2: Simple Roundabout Sign

Figure 3: Sign for 4150 West Approach

Figure 4: Sign for 13000 West Approach

Figure 5: Sign for Riverton Blvd Approach

Figure 6: Sign to inform Drivers locations of road

Pavement Markings

Although the signs give proper warning to drivers about the roundabout, pavement markings are just as important. A proper pavement marking will warn and also spell out the rules of the roundabout. For example, a "YIELD" marking will be placed just before the yield line to enter the roundabout so drivers that aren't familiar with the rules of the roundabout will know to yield (See Figure 7: Pavement Markings on Roundabout Approach). It is also necessary to avoid instructions that confuse drivers. For instance, it was decided that a "YIELD AHEAD" marking on the roundabout might interfere with those utilizing slip lanes, and thus it was left off of the design.

Pavement marking arrows are also very useful in letting drivers know what lane they should be in. Even though the roundabout will only be a one-lane roundabout with slip lanes, arrows are still necessary to guide drivers into and out of the roundabout.

Figure 7: Pavement Markings on Roundabout Approach

Estimated Costs

Costs of the design

Due to the services provided by the team, it will be necessary to charge a fee based on the average hourly wage of an entry-level civil engineer. It is anticipated that each member of the team will spend six hours a week on the project for 12 weeks of the semester. The cost and calculations are listed below:

(6 hours per week per member) x (12 weeks) =72 total estimated hours per team member

The average entry level civil engineer hourly wage is $23.00

Estimated cost per team member is $1,660

Salaries of Team Members

Ben Tuckett	$1,660
Josh Belnap	$1,660
Pete Kelly	$1,660
Rob Naylor	$1,660
Tyson Ferguson	$1,660
Total	**$8,300**

Construction and Maintenance Costs

According to a study commissioned by the Kansas Department of Transportation (Alisogu, 2010), the estimated costs of the construction of a roundabout and its alternative (signalized intersection) are comparable at about $715,000. However, when considering the maintenance over a 30 year lifespan, the main advantage of a roundabout becomes the decreased accumulated maintenance cost, estimated to amount to approximately 90,000 dollars (Alisogu, 2010). Although not addressed specifically in this report, it is also worth considering other ways roundabouts can save money, including time saved not waiting at a signal and fewer pollutants emitted into the environment.

Traffic Analysis

Tuckett & Ferguson used the Synchro Studio 7 software and the HCM to perform a traffic analysis on the proposed intersection in Riverton City. Overall visualization and queuing patterns were observed from Synchro while control delay and LOS were computed using the HCM method to show that the proposed design will serve future traffic growth.

Synchro

An aerial photo with the proposed streets superimposed was used to draw the intersection (Figure 8: Aerial photo of future development.). The intersection of interest for this report is the site which lies furthest to the east. Actual dimensions of the site were entered into Synchro to accurately represent speeds, queue lengths, etc.

Figure 8: Aerial photo of future development.

The Riverton transportation master plan provides average weekday traffic (AWDT) projections for various roads for the year 2030. Of all the streets with an AWDT provided, only one, 4150 west, is a connector to the intersection of interest, lying to the northeast. A peak-hour volume for this leg was assumed most accurate because its AWDT was known.

In traffic engineering, the k-factor is the proportion of the peak-hour traffic to the average annual daily traffic (AADT, in this case, the given AWDT will be used). A 50% directional split and k-factor range of 8-12% were assumed. Of all cars approaching the intersection on 4150 West, 60% were assumed to turn left onto Riverton Boulevard. Once incoming volumes were found, the same amount of vehicles was assumed to exit the intersection onto 4150 West by virtue of the 50% split. Using these values for 4150 West, turning movements for the other two legs were estimated. Table 1 shows the different volumes used to create the Synchro animations.

Table 1: Input Volumes for Proposed Intersection

	4150 W		**13000 S (SE)**		**Riverton Blvd**	
	Left	**Right**	**Left**	**Right (Through)**	**Left**	**Right**
k=.08	439	293	255	128	251	477
k=.09	494	329	287	144	283	536
k=.10	549	366	319	160	314	596
k=.11	604	403	351	176	345	655
k=.12	659	439	383	192	377	715

These volumes were entered into various intersection types in Synchro to give a visualization of how traffic conditions would be under each circumstance. A roundabout design combined with lower k-factors produced the least amount of queueing. In Figure 9 below shows an example of an animation using a roundabout design.

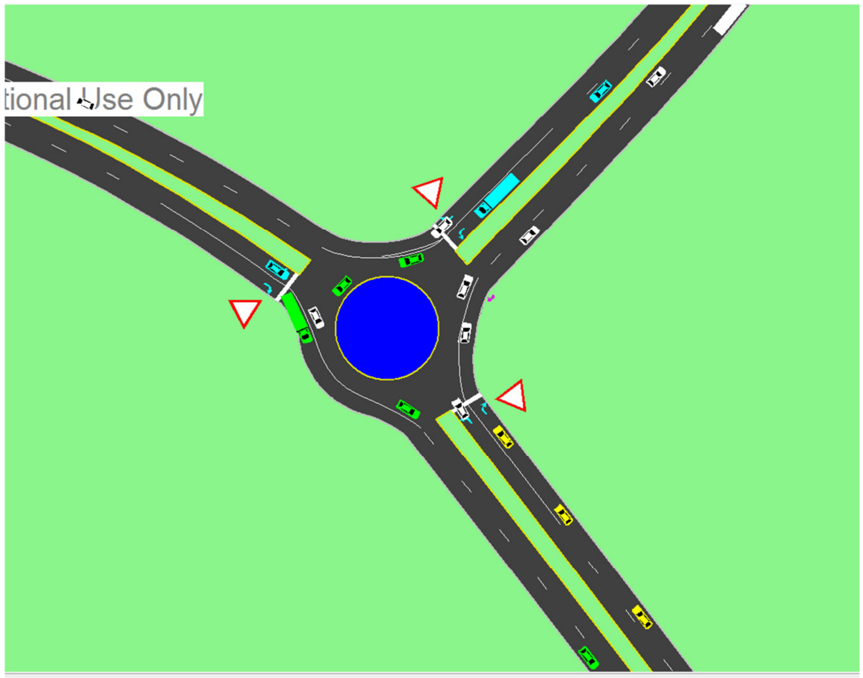


Figure 9: Screenshot of Synchro 7 software

Synchro does not have extensive capability for highway design, creating some confusion regarding the illustration in Figure 9. Although it appears that there are two lanes in the roundabout, there is actually one roundabout lane and one slip lane for each approach. Although the illustration does not show the slip lanes separated from the roundabout, their functionality within Synchro remained the same during simulation. The slip lanes are expected to be slightly separated from the roundabout, as shown in the design section of this paper.

HCM Traffic Analysis

To determine the LOS for the proposed design, the method outlined in Chapter 21 of the 2010 HCM was followed (Transportation Research Board, 2010). Using this method, control delay in seconds per vehicle was calculated at each approach based on the number of conflicting vehicles occupying the circulatory roadway. Since the outside lanes of all approaches in the design are diverted away from the roundabout by the use of slip lanes, the number of vehicles in the circulatory roadway is significantly reduced. Consequently, it was observed that when the proportion of approaching vehicles entering the circulatory roadway is significantly greater than the proportion of vehicles entering the slip lanes, the LOS declines. Table 2 shows the projected control delay and LOS calculated for the intersection using the range of k-factors which were described previously.

Table 2: Calculated Level of Service and Control Delay based on assumed k-factor.

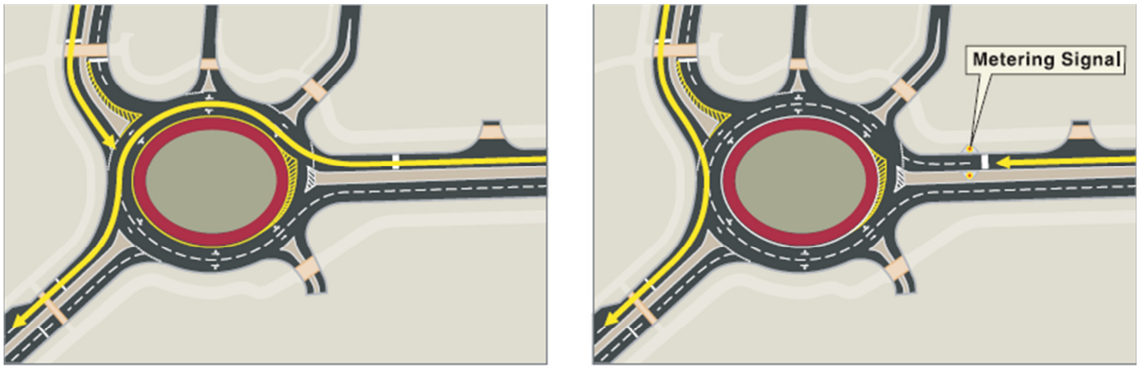
K-Factor	Control Delay (sec/veh)	LOS
0.08	11.00	B
0.09	13.87	B
0.10	19.89	C
0.11	42.28	E
0.12	120.15	F

It should be noted that although 8-12 percent is a typical range for design K-factors on urban arterials, the volumes used to obtain the LOS in this range are only estimations and actual future volumes may differ depending on how the land use of the surrounding area changes over time. It is expected that the actual proportion of AWDT in the peak hour will be closer to 9 percent, which is the standard value that the Florida Department of Transportation (McLeod, 2012) uses in planning and design.

Signalized Metering

Should future peak hour demands rise to an extent which results in an unsatisfactory LOS, it is recommended that signalized metering be implemented at all approaches to the roundabout. Although currently uncommon in practice, signalized metering at roundabouts can be an effective solution to mitigating unexpected significant increases in traffic demand with relatively low costs in comparison to geometric improvements. Roundabout metering is different from traditional signalized intersections in two fundamental ways: 1) with a traditional signalized intersection, signals are in operation at all times except during power failures or if the signal controller malfunctions. With a metering system at a roundabout, signalization would only be needed during peak hours when the queues of vehicles entering are expected to be the longest, much like the operation of metered freeway onramps. 2) Unlike a traditional signalized intersection, only one approach needs to be stopped at a time. This is possible because vehicles at any given approach only need to yield to the vehicles entering from the next adjacent approach in the clockwise direction (assuming vehicular flow is in the counterclockwise direction as is the case in the United States). The only exceptions to this circumstance are when a vehicle is making more than one revolution in the roundabout, or when a vehicle from another approach is making a U-turn. Since these occurrences are usually rarer, they are negligible when considering the design of a metered roundabout.

Logistically, the way metering would work at this particular site is with the use of queue detectors that would be installed a considerable distance away from each approach. When a long queue is detected, the movement at the approach that directly conflicts with the queued approach will receive a red arrow signifying that they may not enter the roundabout. Once the queue is cleared, the conflicting approach again receives a yellow arrow, indicating that vehicles may enter the roundabout after yielding to vehicles already inside. An example of this is as implemented in Clearwater, Florida is shown below (See Figure 10: Metering Signals)**.** This type of metering is most successful when one approach consistently experiences longer queues in comparison with others. In the simulation analysis performed on the Riverton site, it was found that the left turn movement coming from 4150 West is expected to experience considerably more queuing than other movements, much like the example shown. In the case where queues form equally at all approaches, it would be beneficial to alter the metering pattern to stop each approach for a timed period in succession in order to relieve queues at the other approaches.



Without metering signal: At peak times traffic from the east flows continuously, blocking traffic entering from the north.

Metering signal briefly stops traffic from the east, which allows traffic from the north to enter the roundabout.

Figure 10: Metering Signals
Source: *NCHRP Report 672, Roundabouts and Informational guide*

Conclusion

In conclusion, the designed roundabout will work as a very feasible option for the proposed intersection in Riverton. Safety was a major concern in the design of the roundabout. The proposed slip lanes will reduce the amount of vehicles that will enter the roundabout as well as allow vehicles to safely merge and change lanes after the intersection. The provided traffic control devices, which include provided signs and pavement markings, will inform drivers of the upcoming roundabout and which lane they should move into to navigate the roundabout efficiently and quickly.

The roundabout also performed well in the traffic analysis methods used to analyze the capacity and LOS. In the Sychro method, future traffic volumes were calculated and used in the software to analyze the flows and feasibility of the design. In the HCM method, the LOS of the roundabout was calculated to determine the capacity. In both methods they performed well with the future volumes. Adding meters to the approaches of the roundabout can be an option for the future if one of the turning movements becomes more congested than the others.

With Riverton’s expected growth, it is important to provide a fast, efficient, and safe way for drivers to traverse the future roads and intersections. This roundabout will provide these desired attributes.

References

Alisogu, S. (2010). Roundabouts v. signalized intersections: A comprehensive analysis. *Kansas Government Journal*.

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McLeod, D. (2012). *General information on K factor*. Retrieved from http://www.dot.state.fl.us/planning/systems/sm/transition/information/default.shtm

Transportation Research Board. (2010). *Highway capacity manual*.