RESIDENTIAL ELECTRONIC GATE SERVICE RATE STUDY
Orange County, California

RK engineering group, inc.

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Residential Electronic Gate Service Rate Study

Introduction

Many private residential communities in Southern California have utilized electronic or manned (guard) gates to control access to their communities. Typically these residential communities have private streets and have limited access through one or more gate controls. The vast majority of communities with gates use electronic gates for controlling access into their community. Manned gates typically occur in very high-end residential communities and were not studied in this analysis. The service rates for visitors at manned gates are somewhat lower capacity than for electronic automated gates, since they require communication with the guard.

For the most part, electronic gates are either swinging gates or rolling gates depending on the traffic control selected by the developer or homeowner association. While the operations of these two types of electronic gates are somewhat different, functionally they are similar. However, access times do vary somewhat between the two types of gates. For nearly all communities, an electronic gate is accompanied by a traffic directory for visitors to activate the gates, and a resident bypass control system activated by a resident's garage door remote controller. The traffic directories are operated by either entering a code for automatic entrance or requesting access by dialing an individual home owner's telephone system to be let in. Residence activation occurs through the use of an electronic remote control device integrated into their garage door remote control which then immediately opens the gate. Typically there is very little delay with the resident activation in comparison to the time required for visitors to request to open the gate through the traffic directory. Also, many times when a resident or visitor activates the gate, other residents or visitors can follow-up quickly once the gate is opened by the first resident or visitor, which increases the overall service capacity of the gate. This can also result in unauthorized visitors to access the gate.

The gate capacity or service rate (vehicles per hour) of the gates is used to determine the potential queuing which would occur at either the traffic directory or the gate. Typically, residents will queue near the gate, whereas visitors will queue at the traffic directory. Once the peak entering demand is established, then the potential queuing can be determined. The peak inbound demand is distributed between the visitors and residents entering the community. Typically this is approximately 20% visitors versus 80% residents within residential communities.

Once the peak entering demand for visitors/residents and service rate of the gate are determined, the traffic utilization factor (the ratio of the demand to the service rate for both the visitors and residents) can be determined and used to calculate the potential queuing. If there is sufficient entering width for two lanes, queuing for both visitors and residents can be determined separately.

At the present time, there are two methodologies available to determine gate queuing, *Transportation and Land Development* prepared by the Institute of Transportation Engineers (1988), and *Entrance/Exit Design and Control for Major Parking Facilities* prepared by Robert W. Crommelin, P.E. (October 1972). Both of these documents provide methodologies for calculating the potential queuing depending on the peak demand rate and average service rate.

According to the Crommelin report, "research has shown that random arrivals or events in a traffic stream tend to follow the Poisson mathematical distribution. This distribution provides a means

that, if the average rate is known, the probability of exceeding a given volume in a unit of time may be calculated. Thus, if you know the average volume, you may calculate the surges in volume to allow design of reservoir space". This methodology allows for a gate utilization factor to be calculated to then determine the potential queuing. The Crommelin report provides a graph based upon a Poisson distribution to determine the queue length behind the vehicle being served. Similarly, the ITE report includes Poisson distribution equations that can determine the number of queued vehicles, based upon various probability levels.

Purpose and Objectives

The purpose of this study is to determine the hourly service rate capacity (vehicles per hour) of electronic gates at residential communities containing single family detached homes. The results of this study could also be applied to multi-family residential developments, since the service rates is expected to be similar. This study is based on field observations conducted at a total of thirteen (13) existing gated residential communities in Orange County, California in the Cities of Newport Beach and Aliso Viejo. A total of fourteen (14) electronic gate operations were observed in this study.

This study includes analysis of both swinging and rolling style gates. Swinging gates consist of two separate gates where both sides "swing" open, whereas rolling gates consist of a single gate that rolls on a metal track. The observations also account for the type of users entering the sites by identifying residents versus visitors (those using the traffic directory). Hence, the study determines the visitor service rate as well as the resident service rate for a typical residential gated community. The study focused on the PM peak hour (4-6 pm) which has been determined to be the peak entering time for most residential communities. For both types of gates, "sneakers" can follow residents or visitors that activate the gate which actually increases the gate capacity.

Furthermore, as part of this study, the number of vehicles entering and exiting the observed properties during the PM peak hour were counted. This information was utilized to determine the inbound and outbound PM peak hour trip generation rate of single family detached residential use based on the conducted observations and provide a comparison to data published in the *Institute of Transportation Engineers (ITE) Trip Generation Manual*. It should be noted that the trip generation data was collected simultaneously with the service rate data, but it is not intended to be conclusive. It is strictly included as supplemental information to the primary purpose of the study.

Findings

The following findings are obtained from this study:

1. Observed Average Gate Service Rate per User Type:
   - Resident = 320.7 vehicles per hour (Range = 191.5 to 437.8 vehicles per hour)
   - Visitor = 150.6 vehicles per hour (Range = 111.7 to 184.4 vehicles per hour)
2. Observed 95th Percentile Gate Service Rate per User Type:
   - Resident = 209.6 vehicles per hour
   - Visitor = 117.5 vehicles per hour
3. Observed Average Percent Split of Total Entering PM Peak Hour Traffic by User Type:
   - Resident = 79.52%
   - Visitor = 20.48%

4. Recommended Percent Split of Total Entering PM Peak Hour Traffic by User Type:
    - Resident = 80.00%
    - Visitor = 20.00%
5. Recommended Gate Service Rate per User Type:
    - Resident [1] = 210 vehicles per hour
    - Visitor [1] = 115 vehicles per hour
    - Combined [2] = 190 vehicles per hour
6. Comparison of Observed Swinging Gate versus Rolling Gate Service Rates:
    - Swinging gates and rolling gates have similar service rates for visitors (Swinging gates have a 95th percentile service rate of 113.9 vehicles per hour, whereas rolling gates have a 95th percentile service rate of 133.5 vehicles per hour)
    - Swinging gates have more capacity than rolling gates for residents (Swinging gates have a 95th percentile service rate of 286.3 vehicles per hour, whereas rolling gates have 95th percentile service rate of 200.8 vehicles per hour)
7. Observed Average PM Peak Hour Trip Generation Rate:
    a. Inbound = 0.42 vehicles/hour/dwelling unit
    b. Outbound = 0.34 vehicles/hour/dwelling unit
    c. Total (Inbound & Outbound) = 0.76 vehicles/hour/dwelling unit

Site Location and Study Area

This study is based on field observations conducted at a total of fourteen (14) existing gates within a total of thirteen (13) existing gated residential communities in Orange County, California in the Cities of Newport Beach and Aliso Viejo. Eight (8) of the gates were rolling gates and six (6) were swinging style gates. All of the gates were found to be typical for these types of private gate access controlled communities.

The following is a summary list of the observed sites. The location maps of the observed sites are shown in Exhibits A-1 through A-7.

City of Newport Beach:

1. Hillsborough at Spy Glass Hill Road, Newport Beach (40 Dwelling Units with a Rolling Gate)
2. Palisades Dr at Newport Ridge Dr W, Newport Beach (56 Dwelling Units with a Swinging Gate)
3. Whitesands Dr at Newport Ridge Dr W, Newport Beach (21 Dwelling Units with a Swinging Gate)
4. Terrace Ridge at Newport Ridge Dr W, Newport Beach (38 Dwelling Units with a Swinging Gate)
5. Montserrat at Newport Ridge Dr E, Newport Beach (80 Dwelling Units with a Rolling Gate)
6. Mont St Michel/Menton at Newport Ridge Dr E, Newport Beach (169 Dwelling Units with two (2) Rolling Gates)
7. Tesoro at Ridge Park Road, Newport Beach (180 Dwelling Units with a Rolling Gate)
8. Campobello at Ridge Park Road, Newport Beach (90 Dwelling Units with a Rolling Gate)

[1] To be used when there is sufficient entering width for 2 lanes: one for residents and one for visitors.
[2] To be used when only one entering lane is available and is shared between residents and visitors.

City of Aliso Viejo:

9. Kensington at Oak View Dr, Aliso Viejo (154 Dwelling Units with a Swinging Gate)
10. Silver Oaks at Oak View Dr, Aliso Viejo (81 Dwelling Units with a Rolling Gate)
11. Crimson Canyon at Oak View Dr, Aliso Viejo (76 Dwelling Units with a Swinging Gate)
12. Endless Vista at Oak View Dr, Aliso Viejo (115 Dwelling Units with a Swinging Gate)
13. Alastair at Oak View Dr, Aliso Viejo (116 Dwelling Units with a Rolling Gate)

Data Collection

Service rate times were calculated at each location by measuring the time from when the vehicle entered the traffic directory to when it passed through the gate. The location of a typical traffic directory and gate are shown in Exhibit B (the service time was measured once the vehicle reached the traffic directory and then passed the gate). These times were converted to a service rate by the following formula:

$$\text{Service Rate (vehicles per hour)} = \frac{3{,}600 \text{ (sec/hr.)}}{\text{Service time (sec/vehicle)}}$$

Data collection at each of the fourteen (14) studied gates was conducted on a typical weekday (Tuesday, Wednesday or Thursday) during the typical weekday PM peak period from 4:00 PM to 6:00 PM. This is also considered to be the typical peak time of entering (inbound) traffic for residential communities.

At each study gate, the type of the gate was noted as either rolling or swinging. Service times for both visitors and residents were noted on the data collection forms. Service rates for both types of gates were calculated and also combined as a single rate for both residents and visitors

For every inbound vehicle between 4:00 PM and 6:00 PM, the observer noted the time at which the vehicle entered the community, timed how long it took for the vehicle to get from the directory through the gate, and noted whether the vehicle was a visitor or resident. If a vehicle stopped at the directory to type in a key code or call someone, it was categorized as a visitor and the time spent at the directory was included in the service time. If a vehicle did not stop at the directory and instead used a remote control device or followed up a vehicle to gain access, it was categorized as a resident, since that time was much shorter than those vehicles utilizing the traffic directory. Some of these vehicles could be considered "sneakers" that followed either a resident or visitor who activated the gate. Similarly, for every outbound vehicle between 4:00 PM and 6:00 PM, the observer noted the time at which the vehicle exited the community.

Data Analysis

1. Percent Split of Visitors versus Residents

The percentage of entering visitors versus residents for each site was calculated by dividing the total number of visitors or residents that entered between 4:00 PM and 6:00 PM by the total number of inbound vehicles during that time period. Then, the overall average was determined by averaging the entering visitor and resident percentages for each site (see Table 1). Based upon this study, approximately 80% of peak inbound traffic were residents and 20% were visitors.

2. Hourly Gate Service Rate Capacity

For each study site, the observed duration of time in seconds that each resident took to get from the directory through the gate was averaged to determine the average service time for residents at that specific site. The hourly service rate for residents at each site was then determined by dividing the number of seconds in a single hour (3,600 sec./hour) by the average service time for the residents obtained from the previous step.

The same calculation was performed for visitors at each of the sites. Then the data from all the sites were averaged to determine the overall hourly service rate for visitors and residents. The data was also separated by the gate type (rolling versus swinging) to compare the service rates for each gate type. A summary of the calculated service rates for all types of gates is shown in Table 2.

A statistical analysis was performed on the resulting data to determine the standard deviation, coefficient of variation and the 95th, 90th and 85th percentiles for all gate types. The statistical analysis was also performed on the data for both swinging gates and rolling gates. Since for most planning studies the gate types may not be known, it is recommended that the average for all gate types be utilized for determining service rates and calculating potential queuing.

When data from a number of observations and locations is available, there are a few different methods for determining what the appropriate design capacity is. For instance, the Crommelin method is a common methodology for determining gate processing capacity and forecasting vehicular queues at various gate types. The Crommelin report states that gates should be designed to operate at 80% of the average capacity. Other methods state that gates should be designed to accommodate 95% of the average gate capacity.

For this study, both of these two methods were used to derive the recommended design capacity based on the observed data. Based on the observed data at the fourteen (14) study gates, 80% of the average hourly service rate design capacity is 120.4 vehicles per hour for visitors and 256.6 vehicles per hour for residents. Based on the observed data at the fourteen (14) study gates, utilizing the 95th percentile, the service rate design capacity is 117.5 vehicles per hour for visitors and 209.6 vehicles per hour for residents.

By reviewing both methodologies with the data collected at the fourteen (14) electronic gates, recommended gate service rates have been determined by user type. In the case where there are sufficient entering widths to accommodate both a visitor and resident lane, it is recommended that the resident service rate be approximately 210 vehicles per hour and the visitor service rate is recommended to be approximately 115 vehicles per hour. When there is insufficient width available for both residents and visitors, the combined rate of 190 vehicles per hour would appear to be appropriate. It should be noted that in most cases at the sites that were observed, there was sufficient width for residents to bypass visitors at the traffic directory. These recommendations are typical for most gate installations similar to that which were observed during this study.

3. Peak Hour & Trip Generation

The observed data over the two-hour peak period was grouped and organized into fifteen-minute intervals. The peak hour is considered to be the four (4) consecutive 15-minute periods from 4:00 PM to 6:00 PM that had the highest number of total observed trips (inbound plus outbound). Then, for each study site, the trip generation rate was determined by dividing the total peak hour trips for that site by the number of dwelling units at the site.

The PM peak hour trip generation ranges from 0.57 to 0.98 vehicles per hour per dwelling unit. The overall average trip generation rate was then determined by averaging the peak hour data results of the thirteen (13) study sites. The results of this analysis are shown in Table 5. The average inbound rate was 0.42 vehicles per dwelling unit, the average outbound rate was 0.34 vehicles per dwelling unit and the total trip generation rate was 0.76 vehicles per dwelling unit.

The total peak hour trip rate is somewhat less than the ITE (Institute of Transportation Engineers) PM peak hour rates which are 0.63 entering vehicles per hour per dwelling unit (inbound), 0.37 exiting vehicles per hour per dwelling unit (outbound) and a total of 1.00 vehicles per hour per dwelling unit. This data was collected for informational purposes only and not to question the ITE data which included substantially more sites.

Recommendations & Conclusions

Combining the two methods for determining the hourly gate service rate design capacity yields a rate of 115 vehicles per hour for visitors and 210 vehicles per hour for residents. The recommended service rates provide for sufficient variation in actual individual site conditions when there is enough room to accommodate both a visitor lane and resident lane. The entering width will typically allow for an entering resident to bypass the visitor at the gate directory and queue directly at the gate. Therefore, gate queuing for residents should be measured from the gate itself, whereas gate queuing for visitors would be measured from the traffic directory.

To obtain a recommended design capacity for residential gates when there is not sufficient width for two entering lanes, the design capacities for visitors and residents should be based upon a weighted average rate, calculated using the average percentage of residents versus visitors and the recommended design rate for residents and visitors. Based upon this study, it would be 190 vehicles per hour for a single entry lane.

Both the Crommelin and ITE methods for gate queuing use traffic intensity in order to predict the queue length at any given time. Based on the observed data, the average PM peak hour traffic intensity would be equal to the average PM peak hour entering trips per hour divided by the gate design capacity for both residents and visitors. When there is sufficient width for two entering lanes, then the queue length for each lane can be determined.

As the traffic intensity increases towards 1.0, the predicted queue length substantially increases. If the number of dwelling units in the community would lead to a high traffic intensity, hence a long queue length, installing multiple electronic gates is recommended to mitigate traffic intensity at a single electronic gate. Therefore, this study provides numerical data on gate service rates that can be used to predict queuing by both visitors and residents in a community that is controlled by electronic gates. The recommended service rates from this study are as follows:

Gate Condition	Service Rate (vehicles per hour)		
	Visitors	Residents	Both
Two Entry Lanes	115	220	-
Single Entry Lane	-	-	190

RK Engineering Group, Inc. is pleased to provide this study of Residential Electronic Gate Service Rates. A significant effort was placed on this study to evaluate several electronic gates throughout south Orange County. The study will serve to provide service rates for queuing studies at future residential developments. Once the inbound demand is known then the queuing can be determined based upon the appropriate service rate.

RK Engineering Group was assisted in this project by UCI Senior Civil Engineering Team II, which consists of Jeremy Mempin, Natalie Chen, Sara Lay, Selena Lau, Madeleine Ortiz and Alex Vu. The UCI group helped by collecting field data for the overall study. Furthermore, Alexandra Brown assisted in the data analysis and participated in preparing the report for the study. Finally, Ms. Allison Kahn Goedecke provided editorial review of the report to finalize it for publication.
RK Engineering Group hopes that this report will be useful to other transportation engineers and planners for the analysis of queuing requirements for residential electronic gate projects. Very little information on this subject has been published in the past and hopefully this information will be useful to others in the future.

Resources

(1) Stover, Vergil G. and Koepke, Frank J., Transportation and Land Development, Institute of Transportation Engineers, 1988
(2) Crommelin, Robert W., Entrance/Exit Design and Control for Major Parking Facilities, October 1972

Exhibit A

Typical Gate Layout

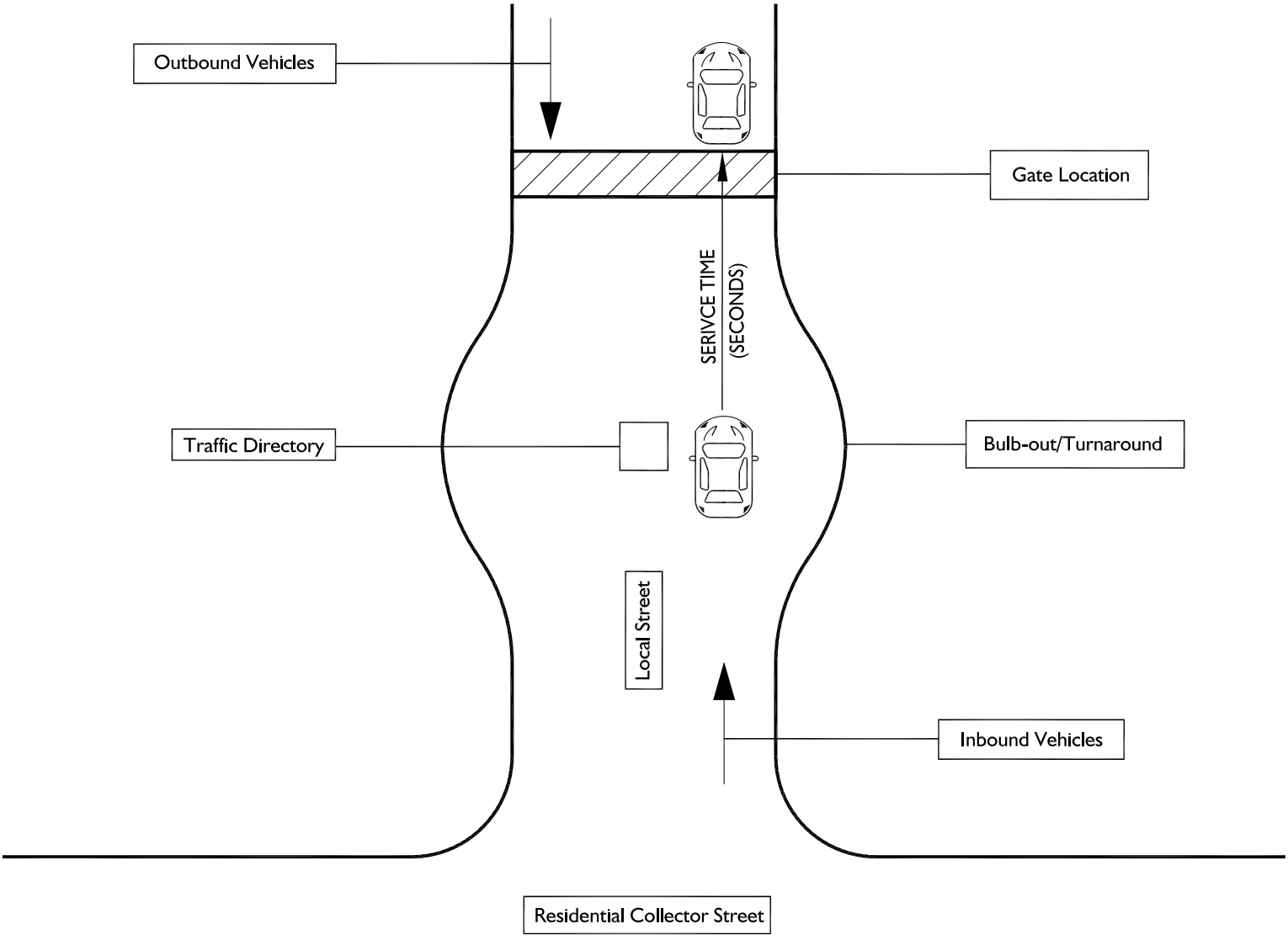

Table 1
Percentage of Visitors vs. Residents Entering Residential Gates

SITE NO.	VISITORS (%)	RESIDENTS (%)
1	32.43	67.57
2	18.18	81.82
3	17.65	82.35
4	44.00	56.00
5	4.55	95.45
6a	21.43	78.57
6b	20.24	79.76
7	16.42	83.58
8	16.67	83.33
9	13.66	86.34
10	24.42	75.58
11	30.00	70.00
12	16.84	83.16
13	10.19	89.81
AVERAGE (%)	20.48	79.52
WEIGHTED AVG.	18.36	81.64

Table 2
Residential Electronic Gate Times and Service Rates (All types of gates)

SITE NO.	VISITOR TIME (SECONDS)	VISITOR RATE (VPH)[1]	RESIDENT TIME (SECONDS)	RESIDENT RATE (VPH)[1]	GATE TYPE
1	25.5	141.1	13.6	265.3	Rolling
2	29.8	120.8	8.2	437.6	Swinging
3	32.2	111.7	8.8	409.1	Swinging
4	20.1	179.2	13.1	273.9	Swinging
5	27.6	130.7	18.8	191.5	Rolling
6a	23.7	152.1	16.3	220.6	Rolling
6b	23.0	156.4	11.9	302.7	Rolling
7	25.4	141.8	10.1	356.0	Rolling
8	25.1	143.6	12.0	301.3	Rolling
9	23.6	152.3	11.0	327.7	Swinging
10	25.8	139.6	15.1	238.6	Rolling
11	19.7	183.2	8.2	437.8	Swinging
12	19.5	184.4	9.8	366.2	Swinging
13	21.1	170.8	10.0	361.6	Rolling
AVERAGE	24.4	150.6	11.9	320.7	Both
STANDARD DEV.	3.8	22.5	3.2	78.3	Both
COEFF. OF VARIATION	15.4	15.0	26.6	24.4	Both
95th %	30.6	117.5	17.2	209.6	Both
90th %	29.1	123.5	15.9	225.8	Both
85th %	27.7	129.9	15.2	237.5	Both
WEIGHTED AVG.	23.5	153.4	11.5	313.5	Both
80% AVERAGE		120.4		256.6	Both
80% WEIGHTED AVG.		122.7		250.8	Both

	RECOMMENDED DESIGN CAPACITY
VISITORS	115.0
RESIDENTS	210.0
COMBINED	190.0

[1] VPH = vehicle per hour