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To whom it may concern,

We are four students at University of Southern California expected to graduate next year, May of 2014. With each of us majoring in a different subfield/subject, we tried to see this project from various perspectives in order to seek what fits best for CHC.

After the insightful site visit, we decided to target ways in which we can improve pedestrian and biker safety as well as for mobility as a whole for the greater Los Angeles. With many traffic-calming techniques already available, we have narrowed down the list to eight specific techniques that we found to be the most reliable and efficient and analyzed them thoroughly. Those eight techniques are chokers, curb radius, raised crosswalks, curb extensions, textured pavements, dignified zones, traffic circles, and midblock crossings. After going deeply into each technique, we have ranked them from top to bottom for you to easily be able to see which ones are the most suitable for Los Angeles.

We have focused this project to cater to CHCs needs and we hope that you find this information helpful for your future plans and projects. Furthermore, we have included references for you to be able to easily find additional information on the given practices. Thank you so much for taking the time to answer our emails whenever we needed any clarifications.

Sincerely,

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# An Analysis of Best Practices in Complete Street Design

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## **Abstract**

In order to improve mobility and safety in Los Angeles, we have looked upon eight distinctive traffic-calming practices. These include chokers, curb radius, raised crosswalks, curb extensions, textured pavements, dignified zones, traffic circles, and midblock crossings. We will go in detail for each of these techniques and in the end, discuss which one would be the better alternative for Los Angeles specifically.

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## 1 Background

Community Health Councils, Inc. (CHC) is a non-profit, community-focused health education and policy organization. Founded in 1992, they strive to advance social justice and increase access to healthcare resources for economically-disadvantaged populations. They are organized into four main policy areas.

**Access and Quality of Healthcare Coalitions** Organize existing community leadership to improve the quality of healthcare services in South Los Angeles. It has two coalitions, the Coalition for Health and Justice and the South Los Angeles Healthcare Leadership Roundtable, which taps into healthcare leaders in the neighborhood to help create an effective, accessible health care system for the South Los Angeles community.

**Expansion and Quality of Healthcare Coverage** Supports local and state coalitions to expand outreach, enrollment, and retention in public healthcare programs. Covering Kids and Families California seeks to expand coverage by reducing barriers to enrollment in health coverage programs. LA Access to Health Care Coverage Coalition represents over 40 community organizations representing low-income, uninsured families. Accessing Benefits for Children is an outreach program that helps families utilize low-cost health coverage.

**Nutrition Resource Development** Works with South Los Angeles locals to advocate for expanding open space and food resources. The Food Policy Roundtable is a coalition to improve food availability, affordability and access in local grocery stores.

**Environmental Health** Seeks to improve the physical community in many ways. These include reducing pollution, converting vacant lots to green space, streetscape improvement that improve mobility, and health-promoting land-use standards. The Coalition for an Active South LA brings together local residents and organizations to make the surroundings more compatible with physical activity.

Through these four policy areas and numerous coalitions, CHC takes an active role in leading the way for a more healthy and livable South Los Angeles.

## **2 Introduction**

The team is composed of three engineering students from the Viterbi School of Engineering and one international relations student from the Dornsife College of Letters, Arts, and Sciences at the University of Southern California. In the fall of 2013, Community Health Councils, Inc. (CHC) approached us to assist them a project of our choosing. After consulting with Gabriel Stover, the Director of Research and Evaluation, and Alex Campbell, the Mobility Policy Analyst, we decided to work with them to get “complete street” policies adopted by the City of Los Angeles. Complete streets allow for pedestrians, bicyclists, motorists, and public transportation users to comfortably utilize streets. Additionally, CHC is pushing for physical changes to streets to improve their use by pedestrians and transit users. We agreed to research complete street practices that have already been proven to be effective in other cities and countries. From this research, we aimed to provide CHC with valuable information and insight into practices that could work well here in South Los Angeles. From this information, CHC would be better positioned to make policy recommendations to the City that could be implemented to improve the pedestrian experience.

### **3 Executive Summary**

Located in South Los Angeles, Community Health Councils, Inc. (CHC) works with a wide variety of organizations, people, and communities through many programs to promote better health policies in the Los Angeles community. We seek to help their organization in its policy recommendations to the City of Los Angeles Mobility Element. Through our research and analysis of complete street practices, we aim to provide insight into ways to improve mobility in the South Los Angeles community.

CHC is producing a report of complete street design guidelines and recommendations to be incorporated into the City of Los Angeles Mobility Element. A key part of this report is detailing the best complete street practices that could be used effectively in Los Angeles. We identified complete street design principles from around the world, including citations, effectiveness, and images of the best ideas. We approached the project with several street design principals in mind: streets are a public space, great streets are great for business, streets need to be designed for the safety of all users, streets can add to green space, and streets should adapt to the current situation. Finally, we looked at cost to determine the feasibility of implanting these practices.

We researched eight different complete street practices used in other parts of the country and world. These included chokers, curb radius, raised crosswalks, curb extensions, textured pavements, pedestrian and restricted traffic zones, traffic circles, and midblock crossings. From this, we created a usability index that ranked the practices. We looked at advantages and disadvantages, effectiveness, and cost and consideration. The practices with the highest usability rating were curb extensions, curve radii, pedestrian zones, and chokers.

## 4 Best Practices

### 4.1 Chokers

Chokers are curb extensions at midblock locations that narrow a street by ultimately creating wider sidewalks. They are also known as safe crosses when marked as crosswalks. Chokers can be made by widening one side of the curb or by bringing both curbs in, giving it the pinch point along the street (See Figure 1). The main purpose of chokers is to decrease speed of incoming vehicles at a mid-point along the streets, create a seamless transition between a commercial and a residential area, and to narrow exceedingly wide intersections [2].



Figure 1: This choker requires drivers to yield upon entering

Two-lane chokers (See Figure 2) leave two lanes in the street cross section narrower than the width of a normal cross section, while one-lane chokers narrow the width to allow travel in only one direction at a time. These chokers are effective for areas with substantial speed problems and streets with minimum or no parking on-site.

#### 4.1.1 Advantages and Disadvantages

The various advantages of chokers are:

- ability to reduce both speed and volume significantly
- easily negotiable by large vehicles (for example, fire trucks)
- improving aesthetic value when well designed

The disadvantages include:



Figure 2: Two-Lane Chokers

- Eliminates on-street parking
- Requires bicyclists to briefly merge with vehicular traffic
- Absence of vertical or horizontal deflation limiting the effect of chokers on vehicle speed.

#### 4.1.2 Effectiveness

Chokers can ultimately increase the visibility of pedestrians as well as to reduce pedestrian crossing width, while the speed of vehicles is reduced by 4 percent on average for two-lane chokers and 14 percent on average for one-lane chokers [14]. Also since chokers work well with speed humps, speed tables, and raised intersections, (See Figure 3) it can be created in many sites with no extreme difficulty.

#### 4.1.3 Cost and Considerations

Factors to consider when creating chokers are to consult with the local fire and sanitation department before setting minimum width and to double check to make sure that the bicyclist safety and mobility are not diminished. Also when reducing two-lane street to one lane, the width of the travel way should not be wide enough for 2 cars to pass at the same time. This equals to the travel way not being wider than 4.9 meter, or 16 to 17 feet; by doing so, the effectiveness of



Figure 3: Speed Hump

the choker is maximized [2]. The cost to create chokers varies depending on the site and landscape but most are along the lines of \$5,000 to \$20,000 (drainage representing a significant amount).

## 4.2 Curb Radius

Curb radius is a traffic calming technique in which the grid of intersecting streets is reshaped and the radius of the curb is significantly reduced. As you can see in Figure 4a, a large curb radius will enable vehicles to go around corners faster while in Figure 4b, a smaller curb radius will slow vehicles down when turning into the corner.

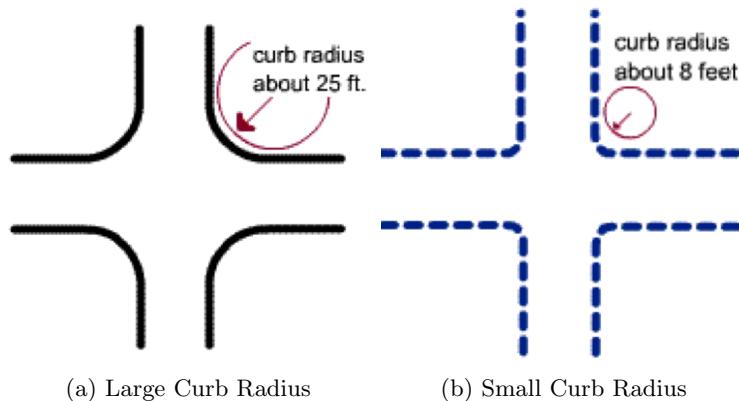


Figure 4: Different curb radii

### 4.2.1 Effectiveness

The purpose of curb radii is to slow vehicles down by enabling them to make smaller turns, which ultimately reduces the risk of pedestrians being struck by vehicles when turning into a corner. Also, small curve radii can create safer intersections, improve the visibility between drivers and pedestrians, and lead to improved signal timing. By reducing the curb radii, not only will it slow down vehicles when turning, but it will also shorten the distance and time it takes for pedestrians to cross the street by nearly half of what it used to be (See Table 1 and Figures 5 and 6).

Curb Radius (ft)	Time (s)
10	7.9
15	9.8
25	14.1

Table 1: Average pedestrian crossing times for various curb radii

When streets have a large curb radius, motorists can make turns at relatively high speeds that decrease pedestrian safety. By contrast, 90-degree intersections and corners with tight curb radii tend to slow motorists down and

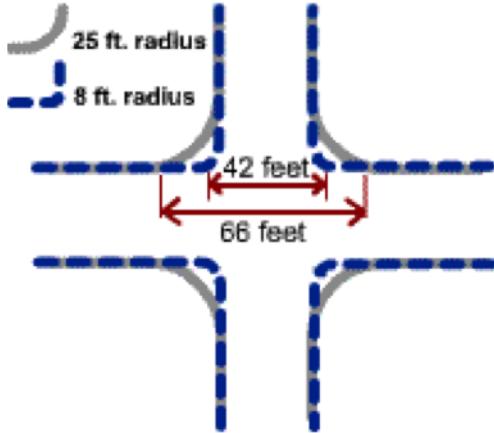


Figure 5: Change in Distance from 25ft. Radius to 8ft. Radius

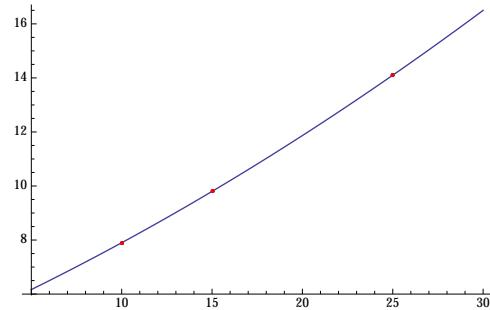


Figure 6: A plot of the data from Table 1

therefore increase pedestrian safety. Motorists turning right at high speed can cut off bicyclists/pedestrians traveling straight on the arterial street. In addition, pedestrians crossing the residential street adjacent to the arterial may not expect high-speed turning traffic, or they may have their backs facing the turning cars as you can see in Figure 7.

#### 4.2.2 Cost and Considerations

The cost of reconstructing tighter turning radii is in between \$5,000 to \$40,000 per corner depending on the site locations/conditions. When considering curb radii, it is important to note that in order for it to be effective, the design should meet the needs of the design vehicles with consideration for nearby land uses and prevalence of roadway users. So if there are high volumes of large vehicles making turns in a given location, a poorly designed curb radius could potentially cause the vehicles to drive over the curb and onto the sidewalk endangering pedestrians. In addition, you should always accommodate emergency vehicles,



Figure 7: Pedestrian Facing Back Against the Car

as well as school buses, and public maintenance vehicles when designing curb radii [6].

There is no magic number for the appropriate curb radius because it differs case by case depending on where it is located (See Figure 8). The length of the curb radius that should be used wherever possible is 5 to 10 feet, whereas an effective radius for urban streets with high volumes of pedestrians is 15 to 20 ft. For arterial streets with a substantial volume of turning buses/trucks, an appropriate effective curb radius is about 25 to 30 ft.; and the maximum desired effective curb radius is typically 35 feet for large vehicles [6].

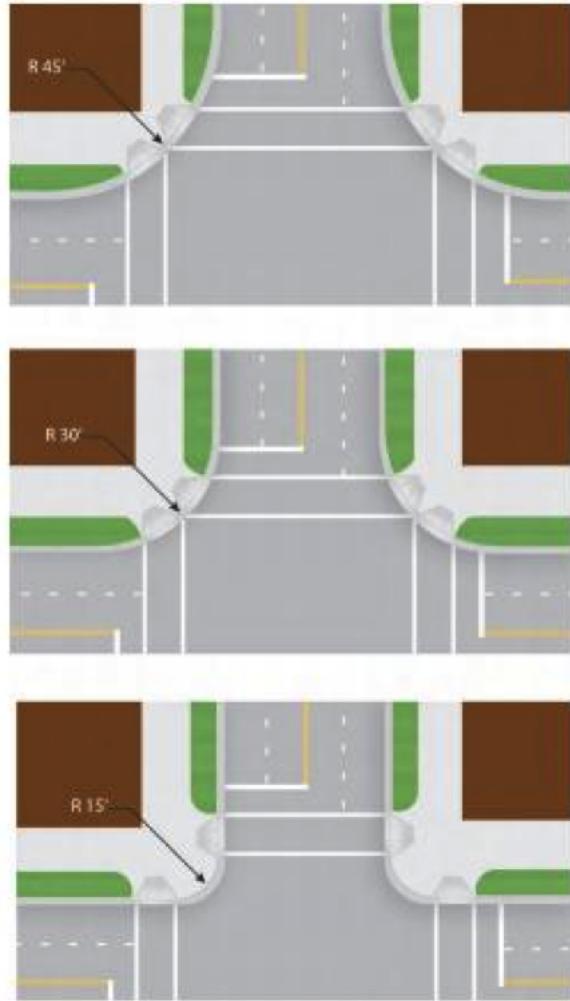


Figure 8: Different Curb Radii Depending on the Location

### 4.3 Raised Crosswalks

A raised crosswalk (Figure 9) is a designated street crossing that simultaneously acts as a speed hump by bringing the level of the roadway to that of the sidewalk.

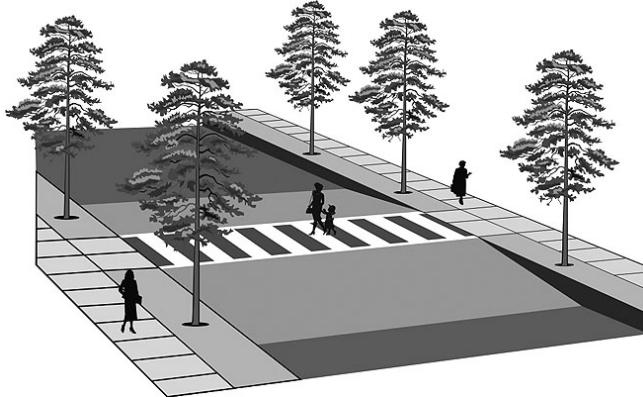


Figure 9: A raised crosswalk [29]

#### 4.3.1 Advantages and Disadvantages

The advantages of such a traffic calming measure include:

- Forces traffic to slow down, improving pedestrian safety.
- Draws attention to the pedestrian, especially when combined with signage and markings.
- Makes crossing the street easier for those on wheelchairs.

The drawbacks are:

- The textured materials used tend to be expensive.
- Not suitable for emergency or bus routes.
- Drainage, especially in snowy or rainy areas, requires additional management.

#### 4.3.2 Effectiveness

Raised crosswalks are an effective traffic calming technique in that they can reduce vehicular speed (See Table 2). Further, they have also been shown effective at encouraging pedestrians to use the crosswalk instead of crossing the road elsewhere. One study [23] found that raising the crosswalk increased the percentage of pedestrians using it from 11.5% to 38.3%.

City and Measure	50th percentile speed (km/h)		Speed reduction (km/h)
	Treatment Site	Control Site	
Durham, NC Research Drive <i>Raised crosswalk</i>	33.3	39.8	6.5
Durham, NC Towerview Drive <i>Raised crosswalk, overhead flasher</i>	18.5	38.4	19.3
Montgomery County, MD <i>Raised Crosswalk</i>	34.6	38.6	4.0

Table 2: Speed reduction due to raised crosswalks (Data from [23])

According to PEDSAFE [23], raised crosswalks can mitigate dart-and-dash type incidents in which the driver was unable to see the pedestrian until just before impact. They also prevent vehicles from ‘trapping’ pedestrians. Raised crosswalks are best used in areas of low-volume, low-speed traffic where safety of pedestrians takes a priority, such as residential areas and near schools. As a side benefit, they make crossings much easier for the elderly, the disabled, and the young in these areas.

#### 4.3.3 Cost and Considerations

The cost of such a crosswalk varies from \$,2000 to \$15,000, with typical cost estimate for one unit being \$4000 [10]. However, this might be significantly increased if a drainage system has to be added.

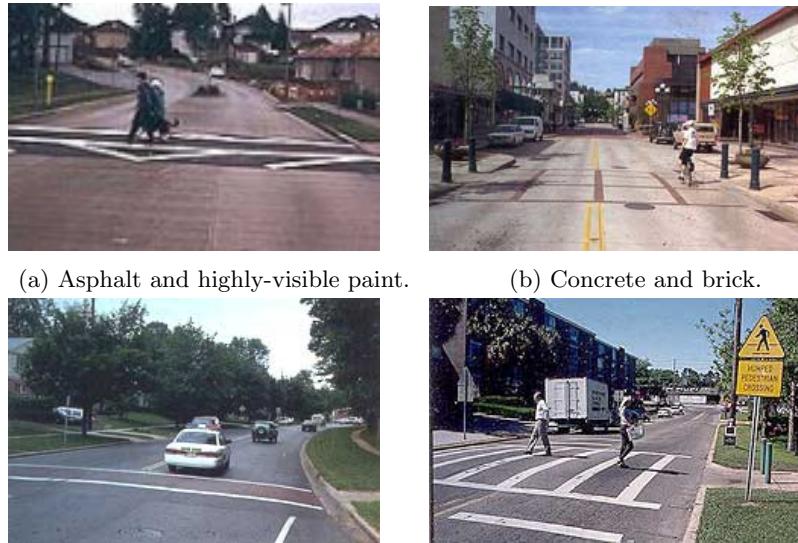


Figure 10: Various raised crosswalk styles. [10]

## 4.4 Curb Extensions

A curb extension (Figure 11) is an extension of the curb onto the roadway. As a traffic calming measure, they are primarily used to assist pedestrians by reducing crossing distance and slowing traffic down.



Figure 11: Curb extension

### 4.4.1 Advantages and Disadvantages

Curb extensions are thought to have the following advantages:

- Reduce the time that pedestrians are exposed to traffic.
- Increase the visibility of pedestrians attempting to cross.
- Shield parking lanes from oncoming traffic and prevent drivers from using them as right turn lanes.

The various drawbacks are:

- They pose a threat to bicyclists, who are forced into a narrowed gap along with traffic.
- Like raised crosswalks, they complicate drainage since they obstruct the gutter.
- Reduce the availability of parking spaces, which can hurt local businesses.

### 4.4.2 Effectiveness

One study [28] found that curb extensions significantly reduced the number of vehicles pedestrians had to wait for before one yielded. The same study also found minor increases in percents of crossings where a motorist yielded, and of vehicles yielding at advance stop bars. These results are shown in Tables 3, 4 and 5.

Lane	Non-curb extension	Curb extension	Difference	Sample Size
Near	2.58	1.81	-42.7 %	219
Far	2.36	1.76	-33.9 %	214

Table 3: Average number of vehicles passing before a pedestrian-cross. Results found significant by the t-test.

Lane	Non-curb extension	Curb extension	% difference	Sample Size
Near	64.9%	66.7%	2.7%	234
Far	58.6%	63.4%	7.7%	234

Table 4: Percents of pedestrian crossings with yield. The results were found insignificant by the t-test.

Lane	Non-curb extension	Curb extension	% difference	Sample Size
Near	42.6%	53.8%	21.0%	99
Far	42.6%	51.9%	18.0%	99

Table 5: Percent of vehicles yielding at advance stop bar. The results were found insignificant by the t-test.

#### 4.4.3 Cost and Considerations

Curb extensions cost between \$5,000 and \$25,000 per corner [4]. As with most sidewalk retrofitting, a large portion of the cost goes to drainage. If it is also necessary to remove a utility pole or other such existing infrastructure element, costs can become much higher.

## 4.5 Textured Pavements

Textured and colored pavements refers to the use of varied pavement materials to alter the color or texture of a street surface. This practice can be used as a traffic calming measure or as a way to distinguish special areas of the street.

Changes in pavement texture from normal concrete or asphalt surfaces can cause a change in audible road noise inside the car body. This effect can be utilized to alert drivers to slow down or take notice of potential hazards. Textured or colored pavements can also be used to visually distinguish special areas of the street, such as crosswalks or bike lanes, to make drivers more aware of their location [18].

Altered pavement textures and colors have been found to cause reductions in vehicle speed, though there is limited data available to quantify this [24]. This practice can be used in combination with other practices to produce a traffic calming effect, such as raised crosswalks, speed tables, or raised intersections.

### 4.5.1 Materials

**Cobblestones** Cobblestone roads are paved with quarried stone with rounded tops. The advantages of this material are that it will create a significant audible disturbance to drivers and can provide a unique aesthetic appeal; however, cyclists and wheelchair users might find this pavement difficult to navigate. Additionally, the unevenness of the pavement makes it more difficult to remove snow and ice [37].



Figure 12: Cobblestone street in Lymm Cross, Cheshire, England

**Setts and Bricks** Setts are quarried stone blocks that are flat-topped (in contrast with round-topped cobblestones). They are typically arranged in a uniform manner, as pictured in Figure 13. Bricks are used and placed in a similar nature, but come from a different source material. The road texture of sett-paved roads can vary depending on the evenness of the selected setts [38].



Figure 13: Streets paved with setts



Figure 14: Speed hump utilizing brick paving

**Concrete Blocks** Concrete blocks are pre-cast, individual blocks of concrete that are placed similarly to bricks or setts. An advantage of using concrete blocks is that they can be shaped and colored in different ways to create a desired appearance. For example, concrete blocks can be made to look like setts and bricks by casting them in a certain size and applying the proper coloring. An additional advantage of concrete blocks is their reduced cost [36].



Figure 15: Concrete block paving

**Colored Pavement** Pavement can be colored through the use of pavement striping paint, as similarly used to make normal pavement markings. While textured pavements generally are made up of more earthen tones, bright colors can be used to create a very noticeable visual effect, as demonstrated by the green bike lanes in Figure 16.



Figure 16: Green-colored bike lanes in Portland

#### 4.5.2 Cost

The cost of utilizing textured or color pavements is dependent on a) the material used and b) the total area of the pavement. The Victoria Transport Policy Institute estimates a cost range of \$5–\$16 per square foot [24]. A crosswalk 10 feet in width crossing a four-lane road, for example, would have a total material cost ranging from \$2400–\$7680.



Figure 17: Brown coloring used to distinguish a bike path crossing in the Netherlands

## 4.6 Pedestrian & Restricted Traffic Zones

### 4.6.1 Pedestrian Zones

A pedestrian zone is an urban area in which motorized vehicle access is disallowed. In some instances, all wheeled vehicles (including bicycles) are banned from the zone. Barriers are typically put in place to physically obstruct motorized vehicles from entering. These barriers typically come in the form of bollards (pictured below) and can be either permanent or removable, if access is required for certain motorized vehicles. Pedestrian zones can be created temporarily by closing off a normal street to motorized traffic by placing temporary barriers. Alternatively, permanent pedestrian zones can be designed without motorized traffic in mind. Figure 18, Figure 20, and Figure 21 illustrate examples of permanent pedestrian zones [21].



Figure 18: Example of pedestrian zone design: enough space allowed in the middle for essential motor vehicles, textured pavements to indicate an alternative purpose for the space, and bike racks in place to encourage bicycle use.



Figure 19: Bollards restricting access to a pedestrian area

Pedestrians zones make land that was previously used for roads or parking available for gathering space or green space. Pedestrian zones increase the local



Figure 20: A temporary pedestrian zone in Tokyo, created by placing temporary barriers in front of a normal street

populations use of walking as a mode of transportation, which in turn decreases usage of automobiles, as businesses in the zone have increased their accessibility to pedestrians. Additionally, these zones are also known to increase rates of physical activity, particularly amongst children [21].



Figure 21: A pedestrian zone

#### 4.6.2 Restricted Traffic Zone

Restricted Traffic Zones are urban areas where non-essential motorized traffic is disallowed. This is a practice most commonly found in Italy, known as a *zona traffico limitato*. The practice is used to reduce congestion and pollution in historical city centers. Cameras are placed at strategic checkpoints entering the zone to check control access. A picture is taken of every vehicle, and its license plate is cross-referenced against a list of permitted vehicles. Prohibited vehicles are fined. Depending on the characteristic of the restricted zone, other vehicles can be allowed as well, such as merchant vehicles, taxis, emergency vehicles, maintenance vehicles, and diplomats [26]. In combination with the

closure of these zones to non-essential traffic, Italian cities increased public transit services to improve mobility. In Milan, for example, this practice proved to reduce automobile traffic in the zone by 50%. In Freiburg, Germany, traffic restriction and public transit improvements caused bicycle usage to double from 1976 to 1986 and led 18% of drivers to switch to public transit [17].



Figure 22: *Zona traffico limitato* warning sign and accompanying cameras

#### 4.6.3 Costs and Considerations

The primary costs of a restricted traffic zone are the construction and maintenance of the monitoring equipment; however, the fines (starting at an equivalent of \$50 in Italy) collected due to violations would make up the difference [26]. One problem with these fines is that it is a nuisance to unsuspecting tourists who are not aware of the laws and fines. Additionally, if measures aren't taken to reduce total automobile traffic through public transit improvements, the traffic that is redirected due to these restrictions could cause significant congestion in other city zones.

The cost of introducing a pedestrian zone to an urban area depends on its design. Table 6 lists selected pedestrian improvements that could potentially be implemented in a pedestrian zone, and their estimated costs based on data from the San Francisco Bay Areas Metropolitan Transportation Commission [32].

Total maintenance costs would also be dependent on the particular facilities. For an example of these costs, one can look to Corona Plaza in New York City. This proposed plaza is currently a dilapidated access road and parking lot, and is planned to be converted to a 13,000 square foot pedestrian public space [31]. It is estimated that it will cost between \$50,000 and \$75,000 a year to maintain this plaza [22].

Element	Estimate	
	Lower	Upper
Paving (textured or non-textured) (per square foot)	\$5	\$16
Concrete Sidewalk Removal and Replacement (per square foot)	\$20	
Pedestrian-Level Street Lights (ea.)	\$3000	\$5000
Cobra Head Standard Lights (ea.)	\$10000	
6 Wide Bench (ea.)	\$1500	\$3000
Bike Rack (ea.)	\$600	\$1200
Bollards (ea.)	\$500	\$750
24 Box Trees (ea.)	\$1820	
Trash Cans (ea.)	\$800	\$1500
Water Fountain (Aesthetic) (ea.)	\$15,000	\$50,000
Tree Grates (ea.)	\$680	\$750
60 Day Maintenance for mile of street (lump sum)	\$3000	\$4000
Signage (Standard vs. High Visibility) (ea.)	\$300	\$400

Table 6: Cost estimates of various elements of pedestrian zones.

## 4.7 Traffic Circles

A traffic circle is a type of circular intersection. It contains a center island, around which traffic flows in one direction. A traffic circle can have one or multiple lanes inside of it, concentric about its center island. Also referred to as a rotary or roundabout, it is capable of handling multiple street inputs. They are commonly utilized throughout New England and Europe.

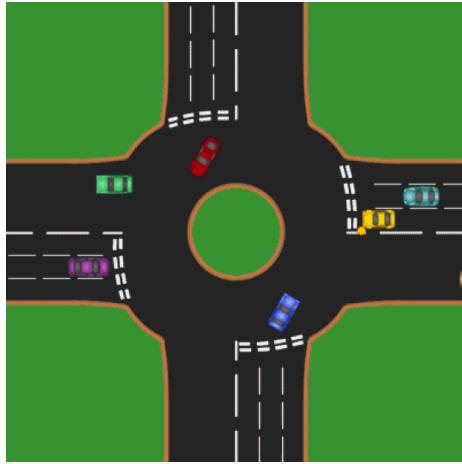


Figure 23: A typical traffic circle for a four way intersection [11]

Unlike a traditional intersection between two perpendicular streets, traffic circles generally do not have traffic lights controlling the flow of traffic. Rather, traffic is controlled by right of way rules. Typically, cars already in the traffic circle have right of way over cars seeking to enter into the traffic circle [20]. Thus, they are designed to slow traffic. Entering traffic typically yields to traffic already in the rotary, and allows for continuous flow of traffic to multiple exits.

Roads can enter a traffic circle radially or tangentially. Roads that enter radially require slowing down of speed and making a turn, thus acting as a traffic calming measure. Roads that enter tangentially do not require as much reduction in speed or turn angle, so traffic is not slowed down as much [12]. Though not as common, entry into traffic circles can also be regulated by traffic lights or stop signs.

Another advantage of roundabouts is that they allow for easy exit to any of the roadways that connect to it. With a normal perpendicular intersection, vehicles wanting to make left or right hand turns instead of continuing straight must wait for specific light signals to turn onto the desire road. With a roundabout, a vehicle simply stays in the traffic circle until reaching its desired exit, which even allows for legal u-turns [11].



Figure 24: Entering traffic must slow and yield to vehicles already in the circle

#### 4.7.1 Advantages and Disadvantages

The advantages of roundabouts are:

- Eliminates T-bone (perpendicular) crashes and head on collisions
- Allows for continuous entering and exiting of traffic to any street
- Improved flow over traffic lights
- Calms traffic by reducing speed without complete stops

Roundabouts come with the following drawbacks:

- Lacks computerized traffic control features
- Can become congested
- Not efficient at moving high volumes of vehicles
- Confusing for inexperienced drivers
- Require driver decision making and timing

#### 4.7.2 Capacity

The capacity of a roundabout is dependent upon the number of lanes within the circle, as well as the diameter of the circle. Most modern roundabouts are less

than 250 feet in diameter [11]. Since it does not necessarily require a full stop by entering vehicles, traffic circles can provide less delay than light controlled intersections. When the volume of entering traffic is unequal between the different roads (unbalanced), there can be inefficiencies. Traffic lights are optimized to maximize the traffic throughput by giving more green lights to a busier road, whereas with a roundabout all roads must slow down and yield to traffic within the roundabout, regardless of the amount of traffic on any particular road [27]. On the other hand, when all of the entering roads experience constant and balanced traffic, a traffic circle can reduce wait times by eliminating red lights.



Figure 25: Perhaps the most well-known traffic circle is the Place de l’Etoile around the Arc de Triomphe in Paris, which has eight lanes with twelve avenues feeding into it.

#### 4.7.3 Mini-roundabouts

One specific type of traffic circle is a mini-roundabout. Mini-roundabouts can be built in places where there is not enough space for a traditional roundabout. They are used in place of a four way stop or traffic light controlled intersection. They improve efficiency by eliminating the delay caused by stop signs and traffic signals.

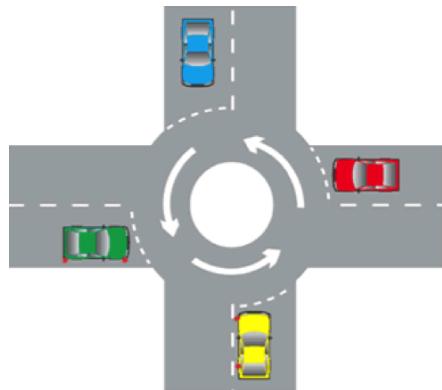


Figure 26: Mini-roundabouts offer greater efficiency than stop signs or lights for intersections with single lane roads.

## 4.8 Midblock Crossings

Midblock crossings are crosswalks that are located on streets in places other than intersections. They are a safer alternative to pedestrians jaywalking at unmarked points. Most crosswalks are located at intersections, where traffic lights allow for vehicles to be controlled in order for pedestrians to safely cross the street. In dense, urban locations with short blocks, this works well. However, in areas with long stretches of road between intersections, it is not always convenient to have to cross at an intersection. Many pedestrians will jaywalk across a street at the location where they need to cross it, not necessarily at an intersection. This can present a hazard to both pedestrians and vehicles, as they could cross the street at any point, and approaching vehicles may not be able to see them. One study shows that midblock jaywalking was responsible for 26.5% of all pedestrian accidents [9].

With long blocks, long signals, wide intersections, and high vehicle speeds, crossing at intersections isn't always easy. It becomes important to identify points at which it is practical and safe to cross roads. Without them, pedestrians make their own decisions to cross at random points, creating risk for both themselves and drivers. By increasing the number of midblock crossings, we hope to decrease the occurrence of jaywalking while improving pedestrian mobility.

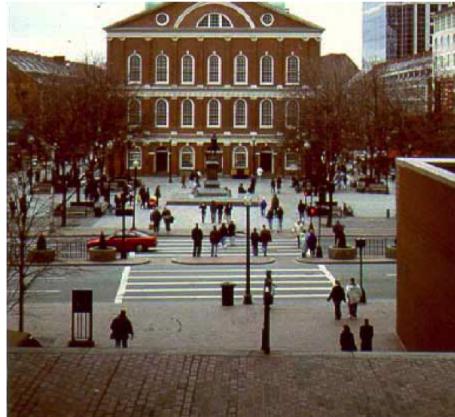


Figure 27: Midblock crossings safely connect public places between intersections.

### 4.8.1 Medians

Medians, also called refuge islands, are often necessary for high volume and high speed roads. Without them, crosswalks are simply too long to cross. They provide a convenient resting area halfway through a crosswalk where pedestrians can safely wait until the other lanes of traffic are safe to cross. It can be difficult to find a suitable gap in traffic for multiple lanes, with traffic heading in both

directions. A median can cut the number of lanes in half by creating two separate crossing journeys, each with traffic in only one direction [15].

For low volume and low speed roads, medians often are not necessary. Gaps in traffic are easier to navigate, and the walking distance across the crosswalk is shorter. For roads with traffic above 30 mph and high traffic volume, midblock crossings should utilize signals and other control devices [15].



Figure 28: Medians divide long crosswalks into two shorter ones.

#### 4.8.2 Signals

Signals are often necessary for multiple lane roads with high speeds, like those found in Los Angeles. With multiple lane roads come a host of traffic conditions, such as vehicles changing lanes and speed. These conditions can make it more challenging for pedestrians to identify gaps, as well as for vehicles to identify pedestrians. With high speeds, traffic signals might be necessary for vehicles to have a sufficient stopping distance before a crosswalk. Large signs, flashing lights, bulb outs and flashing signs have all been shown to work well at midblock crossings [1]. Midblock crossings are not always expected, so motorists might not be looking out for them.

Signals and signage can include:

- Pavement markings
- New signage
- Painted/textured surfaces
- Flashing lights



(a) Stop signs and curb extensions

(b) Flashing lights

Figure 29: Designing midblock crossings with these tools in mind increase pedestrian safety [7]

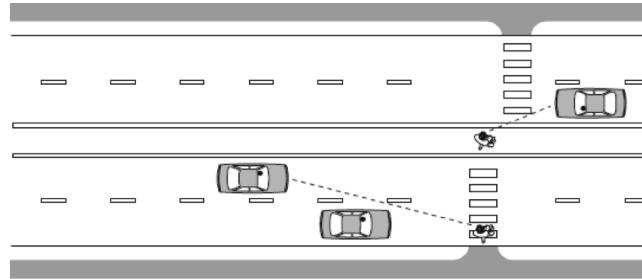


Figure 30: Staggered midblock crossings increase visibility of oncoming vehicles to pedestrians at the median [1].

#### 4.8.3 Staggering

Staggered crosswalks (Z-crossings) are a special type of crossing that contain a median that offsets a set of crosswalks on either side of the median. Since the overall crossing path is no longer a straight line, this forces pedestrians to turn and view oncoming traffic upon reaching the median before crossing the rest of the street [15]. This encourages pedestrians to look for oncoming traffic.

#### 4.8.4 Estimated Costs

Design	Cost
Crosswalk (walk countdown) signal	\$5,000
Curb extensions	5,000–25,000
Basic crosswalks with signs and markings	500–1,500
Enhanced crosswalk with special stencils, raised platforms, or special signage	\$5,000
Raised crosswalks:	
Refuge island (median)	2,000–15,000
In pavement illumination	10,000–40,000
Pedestrian only traffic signal	25,000–40,000
Midblock flashing crosswalk	40,000–75,000
	\$40,000

Table 7: Costs of midblock crossing design elements

## 5 Analysis

### 5.1 Methodology

As part of scope of this project, this group has been charged with ranking the previously spotlighted best practices. The purpose of this ranking system is to concretely define which practices, in the opinion of this group, would be most recommended for implementation into the Mobility Element of the city's General Plan as important street design principles.

The Victoria Transport Policy institute lays out a framework for evaluating traffic calming practices. They identify four factors that influence the effectiveness of a particular project:

**Magnitude of Change** How much of an influence a particular measure has on improving pedestrian and cyclist mobility.

**Demand** Improvements to streets are more effective if more people utilize them. For example, pedestrian facility improvements should be made around busier areas such as schools or commercial centers [24].

**Integration with other improvements** If only one complete street design practice is applied in an improvement project, it has much less of impact than if many other practices were applied in the same project [24].

**Land use effects** Street improvements that promote pedestrianism can cause changes in land use that further encourage people to walk or cycle, such as shops spring up along busy pedestrian corridors [24].

Since the best practices that have been outlined previously are being examined as general practices, rather than as improvements to specific locations, they will be evaluated based on their individual magnitudes of change, how well they integrate with other practices, and the feasibility of implementing them in the context of Los Angeles.

To determine each practice's usability index, a score has been assigned to each practice for four characteristics: magnitude of change, integration with other improvements, viability in Los Angeles, and cost. Each practice is rated 'low', 'medium', or 'high'. These scores are derived from the judgment of group members in combination with ratings of a similar nature from San Francisco's Metropolitan Transportation Commission [33]. The Usability Index score is an agglomeration of these four scores, also with ratings of low', 'medium', or 'high'.

## 5.2 Rankings

Practice	Magnitude of Change	Integration with other improvements	Viability in Los Angeles	Cost	Usability Index
Chokers	Medium	Medium	High	Medium	High
Curve Radii	Medium	High	High	Medium	High
Raised Crosswalks	Low	Medium	Medium	Medium	Medium
Curb Extensions	Medium	High	High	Medium	High
Textured & Colored Pavements	Low	High	High	Low	Low
Pedestrian Zones	High	High	Low	High	High
Traffic Circles	Medium	Low	Medium	Medium	Medium
Midblock Crossings	Medium	Low	High	Medium	Medium

Table 8: Rankings of Best Practices

### **5.3 Discussion**

Upon reflection, select individual ratings stand out, specifically, the ‘low’ rating of pedestrian zones for viability in Los Angeles. The group felt that one particular challenge with implementing pedestrian zones was that in most examples, they were typically put in place in areas with high population density. In the context of Los Angeles, and specifically South Los Angeles, the group felt that it would be difficult to select a location for a pedestrian zone, and that pedestrian traffic should instead first be built up in such a manner that a pedestrian zone would be more accessible when it is finally implemented. That said, the group ultimately rated pedestrian zones with ‘high’ usability index due to the significant benefits they can provide to public health.

Research into the subject found there is no consensus on the ability of textured or colored pavements to reduce vehicle speeds, which significantly contributed to its ‘low’ usability index rating; however, most examples of textured pavement found by the group were in combination with other street elements, such as raised crosswalks, traffic circles, or pedestrian zones. The visual cue that textured and colored pavements provide to drivers and pedestrians, combined with potential aesthetic benefits, make them good accents for other projects, but not viable as a standalone improvement.

In addition to the previously discussed pedestrian zones, the group finds chokers, curve radii, and curb extensions to be of high usability to the city. The commonality between these practices is that they contribute to mobility by creating safer environments for pedestrians, and are extremely viable in a city such as Los Angeles, where there are numerous available location for these practices to be implemented.

## 6 Conclusion

A city's choice of guiding principles behind street design has a large impact on the daily life of its people. This is especially true in an area like Los Angeles, where so many depend on the ubiquitous roads to get between home, work, and school. Thus, it is important that decisions with regard to policy must be made keeping in mind the needs of all parties involved: commuters, pedestrians, residents, and local business owners.

The research that we have done into the 'best practices' currently in use at various locations around the world has revealed telling data on the effects these measures have had on their neighborhoods. The existence of these quantified metrics allowed us to evaluate these practices in an objective manner, and determine which practices would be appropriate for the Los Angeles area.

We hope that our findings will assist the CHC with selecting and promoting better mobility policies. Should these be successfully petitioned to our policymakers, they will translate into streets that are safer and cleaner.

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# James (Jake) Hermle

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## EDUCATION

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**University of Southern California**, Los Angeles, CA

Viterbi School of Engineering

Bachelor of Science, Civil Engineering

Expected May 2014

Cumulative GPA: 3.668

**Honors:** Viterbi Dean's List, Presidential Scholar, Chi Epsilon Honor Society, Rusch Engineering Honors Program

**Thomas Jefferson High School for Science and Technology**, Alexandria, VA

June 2010

GPA: 4.319

## EXPERIENCE

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**Arup**, Los Angeles, CA

Summer 2012, Summer 2013

*Infrastructure Intern*

- Modeled light rail underground guideways to perform soil settlement analyses.
- Produced horizontal and vertical roadway alignments for the Gerald Desmond Bridge Replacement Project.
- Chaired civil engineering group task force meetings and took minutes.
- Coordinated with the NOAA PORTS program to determine design constraints for bridge air gap sensor.
- Created utility routing plan for pipes servicing Gerald Desmond Bridge maintenance vehicles.
- Produced potholing and CCTV surveying exhibits for utility upgrading projects.

**Dominion Virginia Power**, Woodbridge, VA

Summer 2011

*Design Intern*

- Designed new service lines to connect businesses and residencies requesting electricity to the power grid.
- Communicated with customers to configure power line designs to individual needs.

**American Society of Civil Engineers, USC Chapter**

January 2011 - Present

*Concrete Canoe Co-Captain (August 2011 – Present)*

- Manage a team of 30 students to design and construct a concrete canoe to be raced against other universities in the Pacific southwest.
- Coordinate team paddling practices, design and construction meetings.
- Developed concrete mix design using lightweight aggregates to design a concrete mix that floats in water while staying within ASCE rules and regulations.
- Composed technical write-ups of the design and construction of the canoe.

**Troy Camp, USC**

September 2012 – Present

*Counselor*

- Assisted in the organization of specialized programming for students at West Vernon Elementary in musical theater and leadership programming for middle school students in the Leaders In Training program.

**Institute of Transportation Engineers, USC Chapter**

April 2011 - Present

*Publicity Chair (August 2011 – August 2012)*

- Helped establish newly formed chapter of ITE.
- Maintain communication with member base concerning ITE events.

## SKILLS

---

**Software:** MS Office (Word, Excel, Powerpoint), AutoCAD, Revit Architecture, SolidWorks, SAP2000, MicroStation (+InRoads)

**Languages:** Conversational German

# Nakul Joshi

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## EDUCATION

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### B.S. Computer Engineering/Computer Science

University of Southern California GPA: 3.575/4

#### Relevant Coursework

Data Structures	Computer Architecture	Object-oriented Programming	Software Engineering
Web Publishing	Calculus & Statistics	Artificial Intelligence	Digital Forensics

Expected Graduation May 2014

## TECHNICAL SKILLS

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**Languages** Java, C/C++, Python, HTML, JavaScript, Verilog

**Tools** Eclipse, NetBeans, SVN, Git, Mathematica, Xilinx ISE

**Packages** Microsoft Office, L<sup>A</sup>T<sub>E</sub>X

## WORK EXPERIENCE

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### Viterbi School of Engineering

*Undergraduate Teaching Assistant, Data Structures*

January 2013 - Present

*Los Angeles, CA*

- Led lab sections for the course.
- Graded assignments and tests.
- Held office hours during which I answered students' questions.

### University of Paderborn

*Research Intern*

May 2012 - July 2012

*Paderborn, Germany*

- Co-authored a paper on Digital Rights Management (DRM) with a Ph.D. student.
- Gained a background in cryptography through research and applied it to develop a protocol for a cloud-based DRM solution.

### Viterbi Academic Resource Center

*Peer Tutor/Supplemental Instruction Leader*

January 2012 - Present

*Los Angeles, CA*

- Assisted students with engineering classes in one-on-one sessions.
- Led weekly group sessions to supplement introductory computer science lectures.

## PUBLICATIONS

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**Towards practical privacy-preserving Digital Rights Management for Cloud Computing** IEEE CCNC 2013  
*Co-author*

- Created a cryptographic protocol that protected the copyright on cloud-based software.
- The protocol specifically protected the privacy and anonymity of users in the system.

## ACADEMIC PROJECTS

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### Factory simulation

Fall 2011

- Collaborated with seventeen students to simulate a multi-agent system.
- Designed and implemented the user interface.

### Constraint Satisfier

Fall 2012

- Wrote a program that found boolean assignments that satisfied a given set of logical statements.
- Applied the program to create a Sudoku-style puzzle solver.

## HONORS AND ACHIEVEMENTS

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### Dean's List

Fall 2010, Spring 2011, Fall 2011, Spring 2012

### Engineering Honors Colloquium

**Southern California Regional International Collegiate Programming Contest**  
*Placed 6<sup>th</sup> out of over 90 teams*

Fall 2010

### IEEE Eta Kappa Nu Honors Society

Member since Spring 2012

# JOHN TIMOTHY LALLY

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**BS in Mechanical Engineering**  
**Minor in Engineering Management**  
Viterbi School of Engineering  
University of Southern California

Expected 12/2014

## Relevant Coursework:

Fundamentals of Physics I, II, III	Strength of Materials
Technical Entrepreneurship	Statics, Dynamics
Introduction to Computational Methods	Engineering Statistics
Probability Concepts in Engineering	Thermodynamics
Fluid Dynamics	Materials Science
Mechophtronics Laboratory	Heat Transfer
Computational Solutions to Eng. Problems	Aero-Mechanical CAD
Linear Control Systems	Flight Mechanics

## Work Experience:

### **Co-op Mechanical Engineer**

Carlisle Interconnect Technologies

5/2013 – 8/2013  
Cerritos, CA

- Utilized engineering principles, processes, and methods to satisfy project objectives related to manufacturing support/development of connectors/cable process
- Created plant and equipment layouts, wrote manufacturing procedures and specifications, investigated and corrected process and tooling abnormalities
- Led investigation and implementation of SPC program on five production lines
- Trained in ITAR and EAR compliance for aerospace and military technology

### **Student Associate**

USC Stevens Center for Innovation

5/2013 – Present  
Los Angeles, CA

- Member of Operations Team for technology licensing and commercialization
- Reviewed technology disclosures from professors and graduate students in Viterbi School of Engineering, Information Sciences Institute, and Keck School of Medicine
- Improved and developed business processes, reviewed data accuracy and metric reporting, and provided input on projects and strategic decisions

### **Construction Manager**

Summer Real Estate

5/2008 – 8/2012  
Boston, MA

- Maintained and updated Boston-area residential properties
- Designed and led remodeling and renovation projects
- Carpentry, roofing, flooring, heating, electrical, plumbing

### **Valet Attendant**

Chatham Bars Inn Resort and Spa

5/2012 – 8/2012  
Chatham, MA

- Provided valet, bellman, and chauffeur services to resort guests
- Managed department operations as bell captain during evening shifts

## Affiliations/Leadership:

### **Delta Chi Fraternity – House Manager**

1/2011 – Present

- Developed projects with Alumni Board of Trustees and USC Housing officials
- Led 10 member committee in planning and executing construction projects

### **National Organization for Business and Engineering – Officer of Investments**

1/2011 – Present

- Planned guest speakers, networking events, and professional workshops

### **Rocket Propulsion Laboratory – Junior Member**

9/2010 – 5/2012

- Cut carbon fiber and constructed wet-layup fiberglass body

# Christine Noh

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CN

## Education

---

Smith College, Northampton, MA.

Date Attended: August 2010 – May 2011

University of Southern California, Los Angeles, CA.

Expected Graduation Date: May 16, 2014

Major: *Bachelor of Arts* – International Relations

## Skills/Qualifications Summary

---

- Bilingual; Ability to speak and write English and Korean fluently with no grammatical errors.
- Avid user of Microsoft Word, PowerPoint, and Excel.
- Experience with both PC and Macintosh computers
- Able to work calmly with various groups of people under difficult situations and communicate well with others.

## Professional Experience

---

Paralegal at Law Offices of Kyung Hee Lee, PC (March 2013 – August 2013)

- Assisted an attorney with various types of immigration cases, and accumulated extensive experience in the areas of B-1; E-1/2; F-1; employment-based immigration petitions (1st, 2nd and 3rd preferences); H-1B; L-1; TN; NIW; all family-based immigration petitions; and extensions/transfers for the aforementioned nonimmigrant visas - strong background in E-2, EB-1, 2 and 3, H-1B and L-1