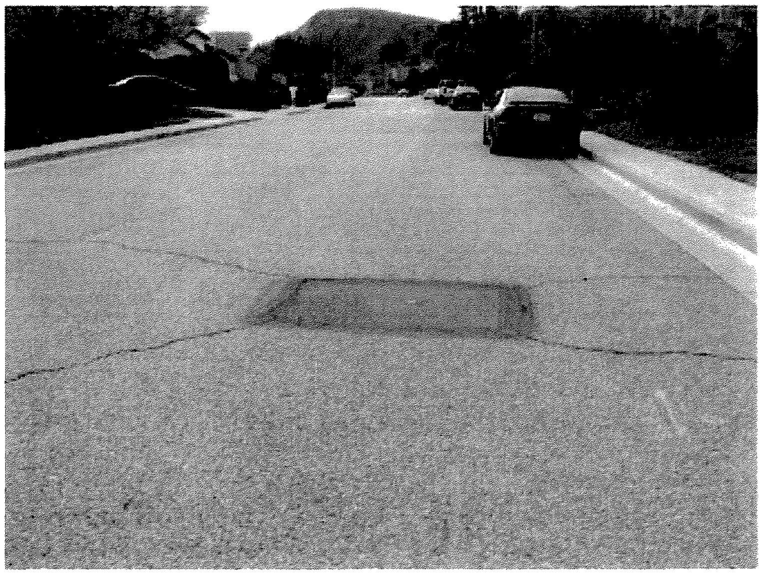
# Street Damage Restoration Fee Study



## City of Los Angeles

**Department of General Services**

**Bureau of Street Services**

**Shahin and Associates**

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## Chapter 1: Introduction

This report presents the results of a study conducted by the City of Los Angeles to update the findings from the Street Damage Restoration Fee (SDRF) study that was conducted in 1996. The objective of this update is to assess the effect of utility cut patching on pavement functional life, pavement structural life, and the incurred extra pavement rehabilitation cost.

A total of 78 pavement sites were randomly selected (Chapter 2) for this study; 30 of the sites are City classified as "Local" and 48 sites are classified as "Select". All sites are flexible (asphalt) pavements as was in the 1996 study. Each site had two adjacent inspection units; one unit had utility cut patches while the adjacent unit did not.

The pavement functional condition and analysis (Chapter 3) were conducted using the Pavement Condition Index (PCI) method, ASTM Standard D-6433, and the City PAVER pavement management system database. Both the PCI and the PAVER system were developed by the U S Army Corps of Engineers.

The pavement structural condition and analysis (Chapter 4) were conducted using the following techniques:

- The Falling Weight Deflectometer (FWD), ASTM-4695, was used to measure pavement deflections of patched and non-patched inspection units. It was also used to determine the size of the area around the utility cut patch that was structurally weakened.
- Pavement coring to determine pavement structure.
- Piezocone Penetration Testing (CPTU) was performed to measure soil strength in the patched and non-patched inspection units.
- DARWin (Pavement Design Program) to calculate overlay thickness requirements.

The overall study summary and conclusions are presented in Chapter 5.

**Chapter 2: Selection of Pavement Test Sites**

Every effort was made to ensure that the test sites were randomly selected, yet proportioned to the number of cuts made by the different utility companies. Great use was made of the City's Bureau of Engineering (BOE) utility cut database as well as the Bureau of Street Services (BSS) PAVER pavement management system database. All test sites were flexible asphalt surfaced pavements. The contract for this project specified the selection and testing of 30 Local (LO) sites and 50 Select (SE) sites. In each of the selected sites two adjacent inspection units meeting ASTM Standard D-6433 (an inspection unit must be greater than 1500 sf.) were established. One of the inspection units is to contain the utility cut patch and the other is to be free of utility cuts and serve as a control that has the same pavement structure and subjected to the same traffic.

The following criterion were used to identify candidate sections:

1. The following fields (BOE database) must be populated; Patch reference number, Utility Company, Date patch was approved, PAVER Section Id.
2. The date the patch was approved by BOE must be after the pavement section last construction or overlay date (PAVER database), otherwise the targeted patch has been covered.
3. The pavement section where the patch is located is greater than 200 ft. for Local and 300 ft. for Select (PAVER database).
4. Pavement section Rank is "E" (residential), or "C" (commercial) for Local streets and is "P" (primary), "S" (secondary), or "C" (commercial) for Select streets.
5. Pavements can't have a slurry applied to them (PAVER database) to be able to see the distresses for the PCI determination.

In addition, it is necessary to select pavements with different ages to allow for the development of models for PCI deterioration over time. Also, patches need to be in the pavement for at least few years so that their effect on performance can be evaluated. This requirement is illustrated in **Figure 2.1**. To accomplish these requirements, pavement sections were stratified into 10 groups "a" through "j" as seen in **Figure 2.2**. As seen in group "a", the patch in the section group will be at least 2 years in the pavement before the PCI inspection is conducted. Meanwhile, pavement sections in group "J" will have patches in them for about 11 years.

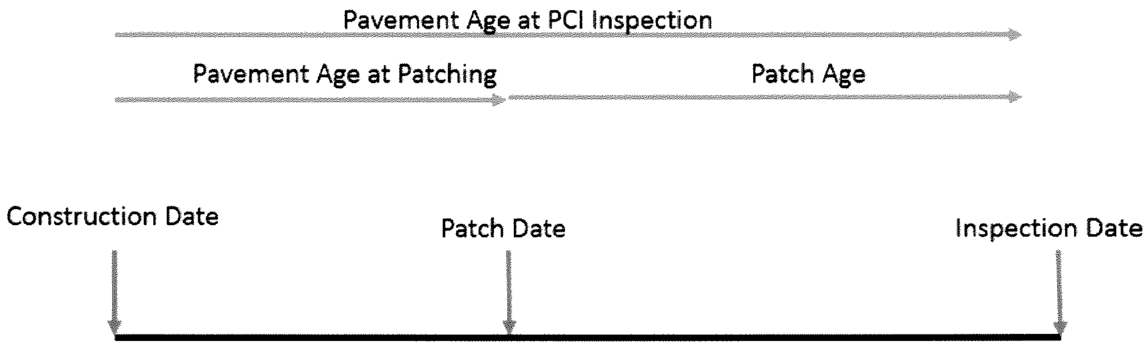



**Figure 2.1** – Pavement and Patch Age Illustration

| Group | Pavement Age in Years at Inspection | Pavement Age in Years at Patching |
|---|---|---|
| a | 3 – 5 | 0 - 1 |
| b | >5 - 7 | >0 - 2 |
| c | >7 - 9 | >0 - 3 |
| d | >9 - 11 | >0- 4 |
| e | >11 - 13 | >0 - 5 |
| f | >13 - 15 | >0 - 6 |
| g | >15 - 17 | >0 - 7 |
| h | >17 - 19 | >0 - 8 |
| i | >19 - 21 | >0- 9 |
| j | >21 -25 | >0 - 10 |

**Figure 2.2** – Pavement and Patch Age Groups

Using the criterions presented above, two lists of candidate sections were created for Local and Select streets. An example is shown in **Figure 2.3**. The last column in that table refers to the patch size in sf. Section with patch size over 30sf. were preferred to facilitate structural evaluation using the Falling Weight Deflectometer (FWD).

Google Earth, along with BOE utility database were used extensively to verify the validity of the candidate sections before going out to the field to mark the patched inspection unit (PAT) and the adjacent control unit (CTL). Items examined included:

1. The referenced patch in the BOE database can be seen in Google Earth.
2. There is enough pavement area without utility cut patching adjacent to the PAT unit to allow for the establishment of the CTL unit. This proved to be a challenging task due to the multiple utility patches in the pavement sections.
3. The PAT and CTL units can't be in intersections or turning lanes to ensure they are subjected to the same traffic.

Great effort was made to include sites from all the pavement groups and to include utility companies in proportion to their number of cuts. To achieve the required number of sites in the contract, the group definitions had to be expanded as shown between parentheses in **Figure 2.4**.

Forty Local sections had to be identified and partially evaluated in the field before the required 30 sited were accepted. The two primary reasons for the loss of the 10 sites were: encountering undocumented concrete layer below the asphalt surface and the asphalt surface thickness in the CTL unit and outside the patch in the PAT unit were not matching. Similarly, 82 sites were partially evaluated in the field before a final 48 sites were accepted. **Figures 2.5, and 2.6** show the final Local and Select sites respectively. **Figure 2.7** is a map of the City showing the locations of the final sites.

| Age Group | Age at Patch, years | Section ID | Reference No | Company | Patch Size (sf) |
|---|---|---|---|---|---|
| b | 0.131506849 | 5417200 | 2008006107 | DWP-Water | 28 |
| b | 0.216438356 | 4790400 | 2011002581 | DWP-Water | 27 |
| b | 1.630136986 | 3363400 | 2011003436 | Time Warner Cable | 123 |
| c | 1.879452055 | 0864300 | 2009004910 | AT&T Light Speed - DWP | 36 |
| c | 2.421917808 | 6067000 | 2011002265 | DWP-Power | 68 |
| c | 0.312328767 | 2609620 | 2006006596 | DWP-Water | 80 |
| d | 1.18630137 | 1601220 | 2007004926 | DWP-Water | 60 |
| d | 0.632876712 | 1601220 | 2005010291 | DWP-Water | 54 |
| d | 2.41369863 | 2776000 | 2008000933 | DWP-Water | 36 |
| d | 2.594520548 | 5241800 | 2008002619 | SoCalGas | 30 |

**Figure 2.3** – Example List of Candidate Sections

| Group | Pavement Age in Years at Inspection | Pavement Age in Years at Patching |
|---|---|---|
| a | 3 – 5 | 0 – 1 (0- 2) |
| b | >5 - 7 | >0 – 2 (0 -3) |
| c | >7 - 9 | >0 – 3 (0 – 4) |
| d | >9 - 11 | >0- 4 (0 -5) |
| e | >11 - 13 | >0 – 5 (0 – 6) |
| f | >13 - 15 | >0 – 6 (0 – 8) |
| g | >15 - 17 | >0 – 7 (0 – 10) |
| h | >17 - 19 | >0 – 8 (0 – 12) |
| i | >19 - 21 | >0- 9 (0 – 14) |
| j | >21 -25 | >0 – 10 (0 – 16) |

**Figure 2.4** – Expanded Pavement and Patch Age Groups

| Trench Number | SectionID | BOE Utility Cut Reference | Trench Location | Last Major Work | Last Inspection |
|---|---|---|---|---|---|
| 1 | 0864300 | 2009004910 | Caldus & Sherman Wy | 12-03-2007 | 10-08-2016 |
| 2 | 4674400 | 2011002265 | 1232 Saginaw St | 01-29-2007 | 10-08-2016 |
| 3 | 1413700 | 2013008181 | 1581 N Crescent Heights Bl | 05-03-2013 | 10-08-2016 |
| 4 | 4711500 | 2013002248 | 4389 San Blas Av | 05-26-1965 | 10-08-2016 |
| 5 | 1318300 | 2012004406 | 23432 Community St | 02-19-2012 | 10-08-2016 |
| 6 | 5417200 | 2008006107 | 17831 Tuscan Dr. | 09-22-1986 | 10-08-2016 |
| 7 | 2609620 | 2006006596 | 9359 & 9369 Hillrose St | 04-01-1960 | 10-08-2016 |
| 8 | 1601210 | 2007004926 | 12950 Discovery Creek | 04-01-2006 | 10-08-2016 |
| 9 | 1601220B | 2005010291 | 12981 Discovery Creek | 04-01-2006 | 10-08-2016 |
| 11 | 4473300 | 2007001354 | Regent St & Motor Av | 08-12-2005 | 10-08-2016 |
| 14 | 2323850 | 2006007102 | 7810 Granito Dr | 05-21-1997 | 10-08-2016 |
| 15 | 2542400A | 2004004683 | 9710 Helen Av | 03-29-2000 | 10-08-2016 |
| 17 | 2542400B | 2004010495 | 9738 Helen Av | 03-29-2000 | 10-08-2016 |
| 18 | 3280200 | 2004007007 | 19325 Londelius St | 05-10-1968 | 10-08-2016 |
| 19 | 3901500 | 2005004215 | 825 Nimes Rd | 07-07-1998 | 10-08-2016 |
| 20 | 5326500 | 2004002287 | 8525 Tobias Av | 05-07-1996 | 10-08-2016 |
| 21 | 5217600 | 2011002581 | 350 Surfview Dr | 04-24-2002 | 10-08-2016 |
| 22 | 5241800 | 2008002619 | 14303 Sylvan St | 10-30-2005 | 10-08-2016 |
| 23 | 1817900 | 2003004036 | 4550 Ensenada Dr | 01-07-2002 | 10-08-2016 |
| 24 | 2194400 | 2003000359 | 24720 Gilmore St | 10-26-1965 | 10-08-2016 |
| 25 | 2948700 | 2006009217 | 3628 & 3634 Kinney St | 11-20-2002 | 10-08-2016 |
| 27 | 4664200 | 2006005590 | 17442 N Rushing Dr | 08-05-1977 | 10-08-2016 |
| 28a | 3363400A | 2011003436 | 22326 Lull St E/o Nita Av | 09-30-1999 | 10-08-2016 |
| 28b | 3902700 | 2011003436 | 7653 Nita Av N/o Lull St | 12-01-1978 | 10-08-2016 |
| 32 | 2837600 | 2010007420 | 9240 Jordan Av | 01-24-1989 | 10-08-2016 |
| 35 | 1831900 | 2008000575 | Erwin St & Reseda St | 12-06-1995 | 10-08-2016 |
| 36 | 5922000 | 2005009092 | 319 S Westlake Av | 09-30-1992 | 10-08-2016 |
| 37 | 1480300 | 2005000697 | 3924 & 3930 Davana Rd & Murietta | 03-08-2002 | 10-08-2016 |
| 38 | 1022000 | 2009001138 | 5060 Cavanagh Rd & Marianna Av | 02-01-2001 | 10-08-2016 |
| 39 | 2805300 | 2008008257 | 3636 Jasmine Av & Tabor St | 03-24-2006 | 10-08-2016 |

**Figure 2.5** – Final List of Local Sites

| _Trench Number | SectionID | BOE Utility Cut Reference | Trench Location | Last Major Work Date | Last Insp. Date |
|---|---|---|---|---|---|
| 3 | 4601800 | 2007012855 | Roscoe Bl & Cozycroft Av | 11-21-2006 | 10-08-2016 |
| 4 | 1507000 | 2008000532 | De Soto Av & Community St | 07-13-2002 | 10-08-2016 |
| 5 | 5928700 | 2010003395 | 812 Westmont Dr Unit & Barrywood Av | 06-12-2008 | 10-08-2016 |
| 8 | 4135200A | 2005001709 | 6600 Owensmouth Av & Vanowen St | 10-09-2003 | 10-08-2016 |
| 9 | 1339200 | 2007004249 | Corbin Av & Dearborn St | 07-20-2001 | 10-08-2016 |
| 10 | 4964300 | 2004006696 | 18011 Sherman Wy & Hesperia Av | 11-02-1998 | 10-08-2016 |
| 13 | 5989100 | 2006008172 | Wilbur Av & S/o Sherman Wy | 09-15-2001 | 10-08-2016 |
| 15 | 0920700 | 2005008957 | 9919 Canoga Av N/o Lassen St | 04-19-2004 | 10-08-2016 |
| 17 | 5705800_17 | 2003006149 | 12147 Victory Bl & Bellingham Av | 05-13-1998 | 01-03-2017 |
| 18 | 6177800 | 2004000340 | 9601 Zelzah Av & Halsted St | 08-14-2000 | 10-08-2016 |
| 19 | 0398300 | 20040007724 | 10124 Balboa Bl N/o Mayall St | 10-31-2000 | 10-08-2016 |
| 20 | 4842600 | 2004004464 | 21505 Saticoy St & Alabama Av | 06-05-1998 | 10-08-2016 |
| 23 | 0848200 | 2004006571 | 6041 Cadillac Av & La Cienega Bl | 04-08-2000 | 01-03-2017 |
| 27 | 5581500 | 2006004020 | Venice Bl & Western Av | 03-08-2005 | 10-08-2016 |
| 29 | 2534500 | 2009002991 | 6750 Hazeltine Av & Archwood St | 03-14-2005 | 10-08-2016 |
| 30 | 0807100 | 2003007664 | 17032 Burbank Bl & Balboa Bl | 05-02-2003 | 01-03-2017 |
| 32 | 5201900 | 2006003587 | 17315 Sunset Bl & Los Liones Dr | 09-29-2001 | 01-03-2017 |
| 35 | 2534100 | 2006003439 | 7305 Hazeltine Av & Valerio St | 03-09-2001 | 10-08-2016 |
| 36 | 1250200 | 2003008938 | 6912 Coldwater Canyon & Basset St | 12-07-1998 | 10-08-2016 |
| 37 | 5705800B | 2004008989 | 12126 Victory Bl & Laurel Canyon Bl | 05-13-1998 | 10-14-2016 |
| 38 | 5542200 | 2005007066 | 13457 Vanowen St & Sunnyslope | 03-05-1999 | 10-08-2016 |
| 40 | 1604800 | 2008008063 | 3722 Dixie Canyon Av & Inwood Dr | 03-14-2008 | 10-08-2016 |
| 41 | 4943300 | 2006011618 | Sheldon St (NS) & Remick Av | 02-22-2002 | 10-08-2016 |
| 43 | 2035600 | 2006006551 | 14960 Foothill Bl (NS) & Roxford St | 08-07-2003 | 10-08-2016 |
| 44 | 5400400 | 2004001061 | 10185 Tujunga Canyon Bl & Hillhaven Av | 03-15-2001 | 10-08-2016 |
| 46 | 5563200 | 2006009231 | 6203 Variel Av N/o Erwin St | 05-02-1999 | 10-08-2016 |
| 47 | 6061900 | 2003008920 | Hatteras St & Winnetka Av | 05-03-1996 | 10-08-2016 |
| 49 | 4341700 | 2006006808 | Plummer St & Lurline Av | 03-31-2005 | 10-08-2016 |
| 56 | 4899100 | 2004000758 | 11121 Sepulveda Bl & San Fernando Mission | 06-27-1995 | 10-08-2016 |
| 58 | 5351000 | 2009009586 | Topham St & Aetna St | 03-20-2008 | 10-08-2016 |
| 59 | 5258900 | 2009003258 | 8850 Tampa Av & Londelius St | 08-10-2008 | 10-08-2016 |
| 60 | 2027900 | 2006009745 | 7352 Foothill Bl & Mountair Av | 08-02-2006 | 10-08-2016 |
| 62 | 2035700 | 2005007446 | Foothill & Roxford | 08-07-2003 | 11-30-2016 |
| 65 | 6101300 | 2008010342 | 6910 Woodley Av & Basset St | 10-11-2002 | 01-03-2017 |
| 66 | 3331700 | 2009009986 | 6611 Louise Av & Kittridge St | 08-28-2002 | 10-08-2016 |
| 67 | 4602100A | 2010000199 | 20839 Roscoe Bl & De Soto Av | 09-27-2005 | 01-03-2017 |
| 68 | 4602100B | 2009006412 | Roscoe Bl & De Soto Av | 09-27-2005 | 01-03-2017 |
| 70 | 1071800A | 2010008406 | 2034 Century Park West S/o MGM Dr | 05-12-2007 | 12-01-2016 |
| 72 | 4487500 | 2009001072 | Reseda Bl & Kingsbury St | 10-04-2009 | 10-08-2016 |
| 73 | 5817900 | 2012001150 | 1408 W Washington Bl & New England St | 01-29-2010 | 10-08-2016 |
| 74 | 0921100 | 2011001219 | Nordhoff Av & Canoga Av | 04-29-2012 | 01-03-2017 |
| 75 | 4142400 | 2008009189 | 11620 Oxnard St & Irvine Av | 03-18-1998 | 10-08-2016 |
| 76 | 5469400 | 2013005289 | 4773 Valley Bl Unit Tel1 & Cyril Av | 01-09-2012 | 10-08-2016 |
| 77 | 1909600 | 2010003811 | 6024 Fallbrook Av N/o Oxnard St | 03-09-1997 | 10-08-2016 |
| 78 | 1909300 | 2007011307 | Fallbrook Av & Victory Bl | 03-09-1997 | 01-03-2017 |
| 79 | 4637800 | 2005007446 | Roxford & Foothill | 05-08-1996 | 10-08-2016 |
| 80 | 4750100 | 2009007498 | 327 San Pascual | 08-21-2006 | 01-03-2017 |
| 82 | 1071800B | 2009011089 | 2054 Century Park W | 05-12-2007 | 01-03-2017 |

**Figure 2.6** – Final List of Select Sites


**Figure 2.7** – Map of Local (Yellow Pins) and Select (Red Pins) Site Locations

## Chapter 3: Pavement Functional Condition Survey and Analysis

### a. Pavement Condition Index (PCI) Survey Procedure

The PCI condition survey method was developed by U S Army Corps of Engineers to provide a numerical rating of the pavement that agrees with the collective judgement of experienced pavement engineers. The PCI has later become an ASTM standard pavement condition survey procedure (ASTM standard D 6433). The PCI is a 0 to 100 measure of the pavement structural integrity and surface operational condition. It is calculated based on observed and measured pavement distress type, severity and quantity (**Figure3.1**).

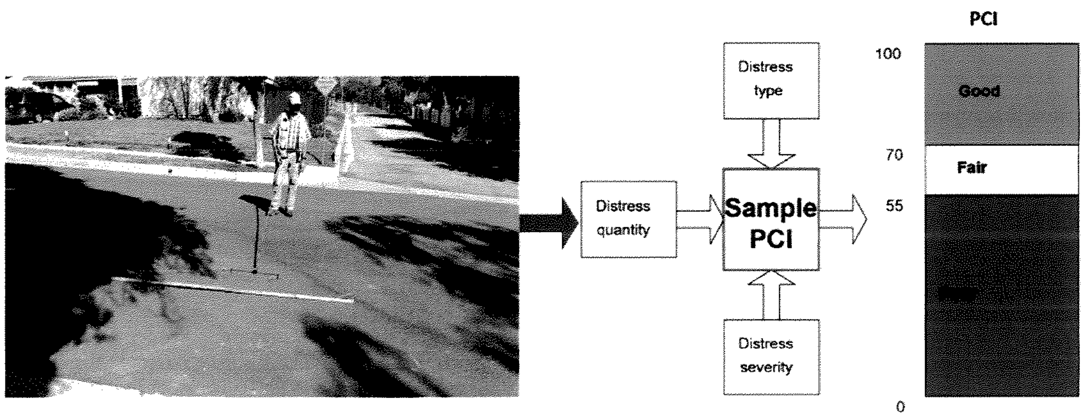



**Figure 3.1** - Pavement Condition Index (PCI) Rating Procedure

### b. PCI Data Analysis

The PCI was determined for each of the selected sites; once for the pavement area that included the utility cut patching (PAT) and once for the corresponding control area that has no utility cut patching (CTL). **Figure 3.2** is a comparison of the area weighted average PCI of the CTL vs. PAT test sites. For the Local streets (LO), the PCI of the CTL is about 15 points higher than the PAT sites. For the Select streets (SE), the PCI of the CTL is about 11 points higher than the PAT sites.

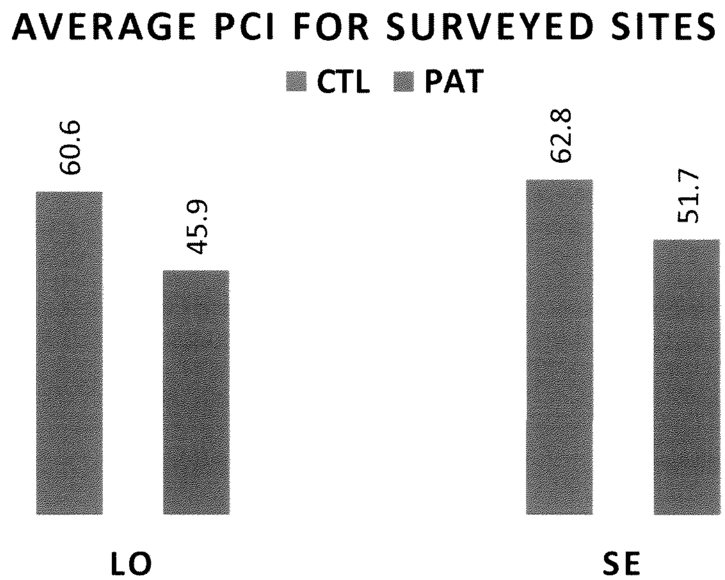



**Figure 3.2** – PCI of Control (CTL) vs Patched (PAT) Inspection Units for Local (LO) and Select (SE) Streets.

### c. Distress Data Analysis

The PCI provides a clear illustration of the negative effect of utility cut patching on pavement condition. Distress, however, provides an insight as of the causes of that negative effect. A complete listing of the distresses found in each site is provided in **Appendices 3.A, 3.B, 3.C, and 3.D** for LO-CTL, LO-PAT, SE-CTL, and SE-PAT respectively. **Figures 3.3, and 3.4** provide a summary of the quantity and Density (percent area) of each distress type and severity combination that was identified in the Local and Select sites respectively.

Alligator Cracking and Rutting are two distresses that are load related. It is to be expected that more of these distresses will occur when the pavement has been structurally weakened. This is clearly the case when comparing theses distresses between the CTL and the PAT sites as illustrated in **Figures 3.5, and 3.6**. In Local streets; Alligator cracking measured at 10.1% of the total surveyed PAT sites as compared to 3.5% in the CTL sites. In Select streets; Alligator cracking measured at 6.8% of the total surveyed PAT sites as compared to 4.2% in the CTL sites. The measured increases are drastic by any standard.

Similar results were observed for Rutting as observed for Alligator cracking. In Local streets; Rutting measured at 1.08% of the total surveyed PAT sites as compared to 0.26% in the

CTL sites. In Select streets; Rutting measured at 2.25% of the total surveyed PAT sites as compared to 1.0% in the CTL sites.

More insight in the effect of utility cut patching on pavement structural condition can be seen in **Figures 3.7, and 3.8**. The figures show a comparison of Alligator cracking between CTL and PAT sites by severity levels. As can be seen, the significant difference is not at the Low severity, but rather at the Medium and High severities. This is another manifestation of the weakened pavement structure due to utility cut patching.

| Distress Code | Distress Description | Units | Severity | LO - CTL Total Quantity | LO - CTL Density% | LO - PAT Total Quantity | LO - PAT Density% |
|---|---|---|---|---|---|---|---|
| 1 | ALLIGATOR CR | SF | H | 68.00 | 0.138 | *1033.00* | *2.023* |
| 1 | ALLIGATOR CR | SF | L | 138.00 | 0.281 | *320.* | *0.627* |
| 1 | ALLIGATOR CR | SF | M | 1,517. | 3.086 | *3806.00* | *7.453* |
| | | SF | Total | 1723.00 | 3.505 | 5159.00 | 10.102 |
| 3 | BLOCK CR | SF | H | 120.00 | 0.244 | *0.00* | *0.000* |
| 3 | BLOCK CR | SF | L | 174.00 | 0.354 | *0.00* | *0.000* |
| 3 | BLOCK CR | SF | M | 3671.00 | 7.467 | *2366.00* | *4.633* |
| | | SF | Total | 3965.00 | 8.065 | 2366.00 | 4.633 |
| 4 | BUMPS/SAGS | | L | 0.00 | 0.000 | 15.00 | 0.029 |
| 4 | BUMPS/SAGS | | M | 0.00 | 0.000 | 30.00 | 0.059 |
| | | | Total | 0.00 | 0.000 | 45.00 | 0.088 |
| 6 | DEPRESSION | SF | L | 232.00 | 0.472 | *285.00* | 0.558 |
| 6 | DEPRESSION | SF | M | 8.00 | 0.016 | *252.00* | 0.493 |
| | | SF | Total | 240.00 | 0.488 | 537.00 | 1.052 |
| 7 | EDGE CR | LF | L | 93.00 | 0.189 | *0.00* | 0.000 |
| 7 | EDGE CR | LF | M | 15.00 | 0.031 | *57.00* | 0.112 |
| | | LF | Total | 108.00 | 0.220 | 57.00 | 0.112 |
| 9 | LANE SH DROP | LF | L | 17.00 | 0.035 | *35.00* | 0.069 |
| | | LF | Total | 17.00 | 0.035 | 35.00 | 0.069 |
| 10 | L & T CR | LF | H | 63.00 | 0.128 | *68.00* | 0.133 |
| 10 | L & T CR | LF | L | 294.00 | 0.598 | *1059.00* | 2.074 |
| 10 | L & T CR | LF | M | 1051.00 | 2.138 | *1858.00* | 3.638 |
| | | LF | Total | 1408.00 | 2.864 | 2985.00 | 5.845 |
| *11* | *PATCH/UT CUT* | SF | H | 0.00 | 0.000 | *224.00* | 0.439 |
| *11* | *PATCH/UT CUT* | SF | L | 0.00 | 0.000 | *2185.00* | 4.279 |
| *11* | *PATCH/UT CUT* | SF | M | 0.00 | 0.000 | *1,206.* | 2.362 |
| | | SF | Total | 0.00 | 0.000 | 3615.00 | 7.079 |
| 15 | RUTTING | SF | L | 50.00 | 0.102 | *310.00* | 0.607 |
| 15 | RUTTING | SF | M | 80.00 | 0.163 | *241.00* | 0.472 |
| | | SF | Total | 130.00 | 0.264 | 551.00 | 1.079 |
| 20 | WEATHERING | SF | H | 0.00 | 0.000 | *260.00* | 0.509 |
| 20 | WEATHERING | SF | L | 19,705. | 40.083 | *20867.00* | 40.862 |
| 20 | WEATHERING | SF | M | 21481.00 | 43.695 | *20906.00* | 40.938 |
| | | SF | Total | 41186.00 | 83.778 | 42033.00 | 82.310 |
| | | | | *Total Surveyed Area* | *49161.00 SF* | *51067.00 SF* | |

**Figure 3.3** – Summary of ALL Local Sites Distresses

| Distress Code | Distress Description | Units | Severity | SE - CTL Total Quantity | SE - CTL Density% | SE - PAT Total Quantity | SE - PAT Density% |
|---|---|---|---|---|---|---|---|
| 1 | ALLIGATOR CR | SF | H | 150.00 | 0.203 | 344.00 | 0.463 |
| 1 | ALLIGATOR CR | SF | L | 1655.00 | 2.242 | 1,803. | 2.425 |
| 1 | ALLIGATOR CR | SF | M | 1,320. | 1.788 | 2887.00 | 3.883 |
| | | SF | Total | 3125.00 | 4.233 | 5034.00 | 6.771 |
| 2 | Bleeding | SF | L | 750.00 | 1.016 | 0.00 | 0.000 |
| | | SF | Total | 750.00 | 1.016 | 0.00 | 0.000 |
| 3 | BLOCK CR | SF | H | 0.00 | 0.000 | 80.00 | 0.108 |
| 3 | BLOCK CR | SF | L | 3238.00 | 4.387 | 2059.00 | 2.770 |
| 3 | BLOCK CR | SF | M | 7849.00 | 10.633 | 6942.00 | 9.338 |
| | | SF | Total | 11087.00 | 15.020 | 9081.00 | 12.215 |
| 6 | DEPRESSION | SF | L | 0.00 | 0.000 | 31.00 | 0.042 |
| 6 | DEPRESSION | SF | M | 0.00 | 0.000 | 121.00 | 0.163 |
| | | SF | Total | 0.00 | 0.000 | 152.00 | 0.204 |
| 10 | L & T CR | LF | H | 40.00 | 0.054 | 10.00 | 0.013 |
| 10 | L & T CR | LF | L | 1319.00 | 1.787 | 2275.00 | 3.060 |
| 10 | L & T CR | LF | M | 753.00 | 1.020 | 1954.00 | 2.628 |
| | | LF | Total | 2112.00 | 2.861 | 4239.00 | 5.702 |
| *11* | *PATCH/UT CUT* | SF | H | 0.00 | 0.000 | 10.00 | 0.013 |
| *11* | *PATCH/UT CUT* | SF | L | 54.00 | 0.073 | 4638.00 | 6.238 |
| *11* | *PATCH/UT CUT* | SF | M | 0.00 | 0.000 | 353. | 0.475 |
| | | SF | Total | 54.00 | 0.073 | 5001.00 | 6.727 |
| 15 | RUTTING | SF | H | 80.00 | 0.108 | 0.00 | 0.000 |
| 15 | RUTTING | SF | L | 610.00 | 0.826 | 1355.00 | 1.823 |
| 15 | RUTTING | SF | M | 50.00 | 0.068 | 315.00 | 0.424 |
| | | SF | Total | 740.00 | 1.002 | 1670.00 | 2.246 |
| 19 | Raveling | SF | H | 0.00 | 0.000 | 10.00 | 0.013 |
| 19 | Raveling | SF | L | 0.00 | 0.000 | 0.00 | 0.000 |
| 19 | Raveling | SF | M | 0.00 | 0.000 | 10.00 | 0.013 |
| | | | Total | 0.00 | 0.000 | 20.00 | 0.027 |
| 20 | WEATHERING | SF | H | 150.00 | 0.203 | 160.00 | 0.215 |
| 20 | WEATHERING | SF | L | 52,638. | 71.310 | 49320.00 | 66.339 |
| 20 | WEATHERING | SF | M | 9555.00 | 12.944 | 7618.00 | 10.247 |
| | | SF | Total | 62343.00 | 84.457 | 57098.00 | 76.801 |
| | | | *Total Sample Area* | 73816.00 | SF | 74345.00 | SF |

**Figure 3.4** – Summary of All Select Sites Distresses

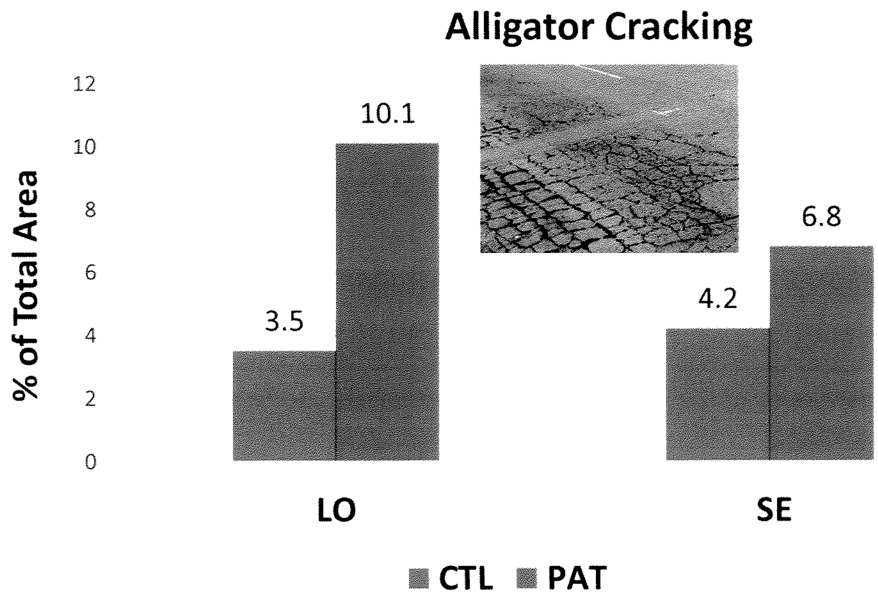



**Figure 3.5** – Comparison of Alligator Cracking % Areas between CTL and PAT Inspection Units for LO and SE Sites

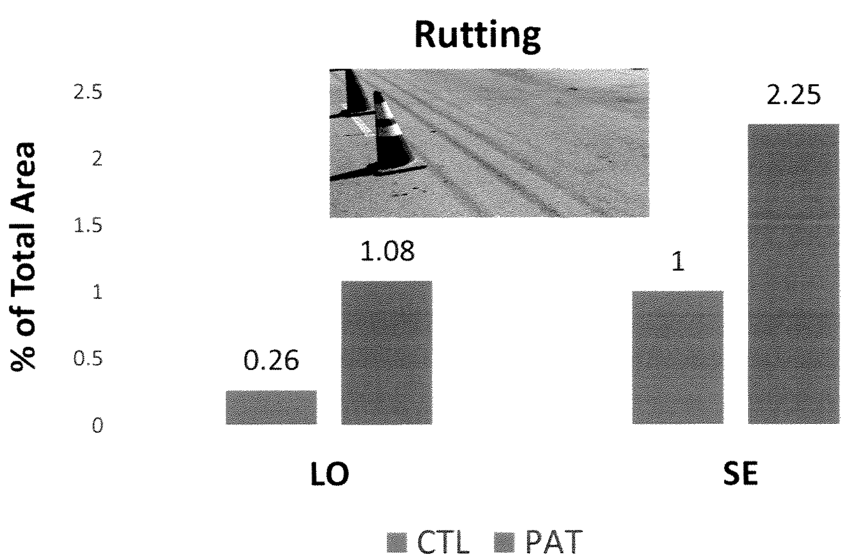



**Figure 3.6** – Comparison of Rutting % Areas between CTL and PAT Inspection Units for LO and SE Sites

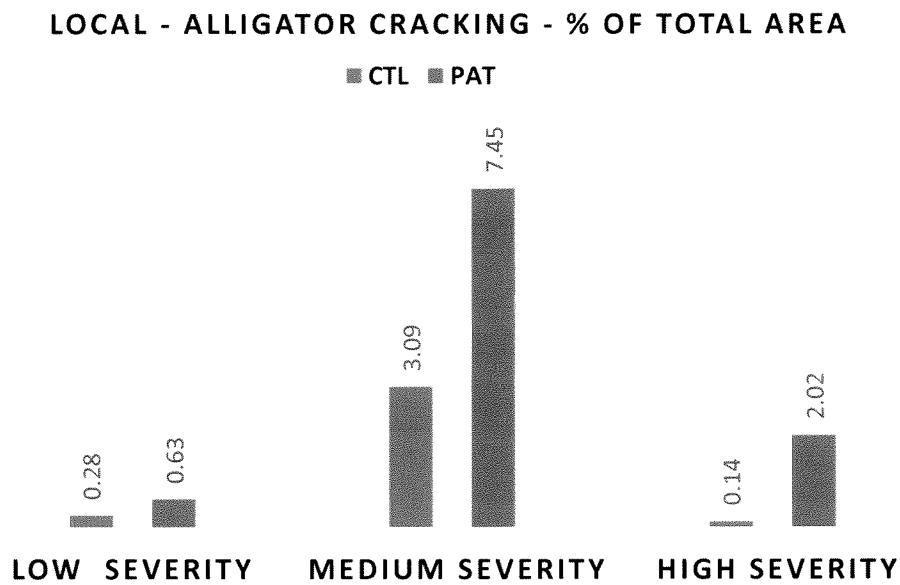



**Figure 3.7** – Comparison of CTL and PAT Alligator Cracking Severity Levels

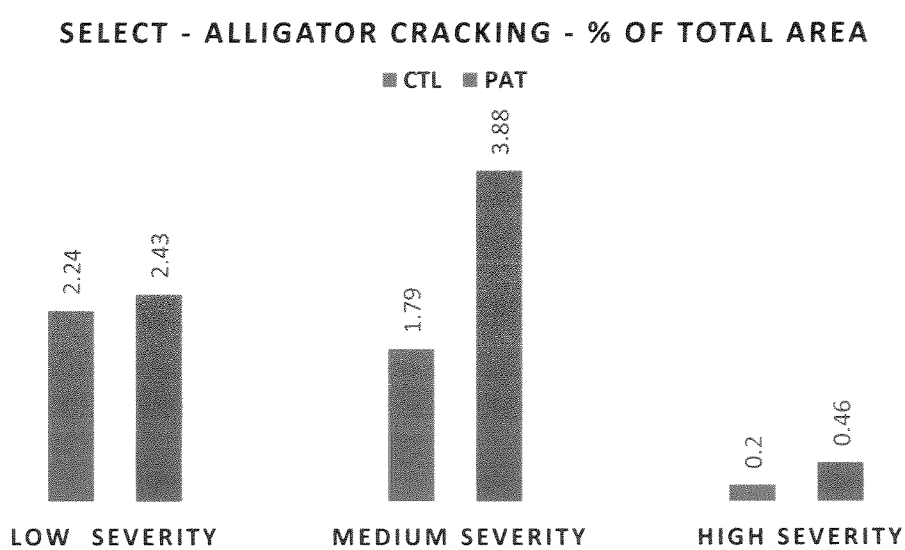



**Figure 3.8** - Comparison of CTL and PAT Alligator Cracking Severity Levels

### d. Pavement Performance and Critical PCI

Pavement performance is defined as condition over time. In this report, the condition is measured by the PCI, and thus performance is PCI over time. **Figure 3.9** shows is a schematic showing an example PCI deterioration over time for a homogeneous group of pavement sections in terms of construction, traffic, and climate. Such a homogeneous group of pavements is referred to as a pavement family and its PCI deterioration curve is referred to as the family model. In a family model, there is a PCI value at which one or more of the following things can occur:

1) The rate of PCI deterioration increases significantly.
2) The pavement area unit cost of preventive maintenance as function of the PCI increases significantly. **Figure 3.10** is an example that was generated using the data in this study.
3) The PCI value is below the desired condition standard for the users

The Critical PCI is the highest value determined based on the three criteria items listed above. The current practice in the City of Los Angeles is to use a Critical PCI value of 60.

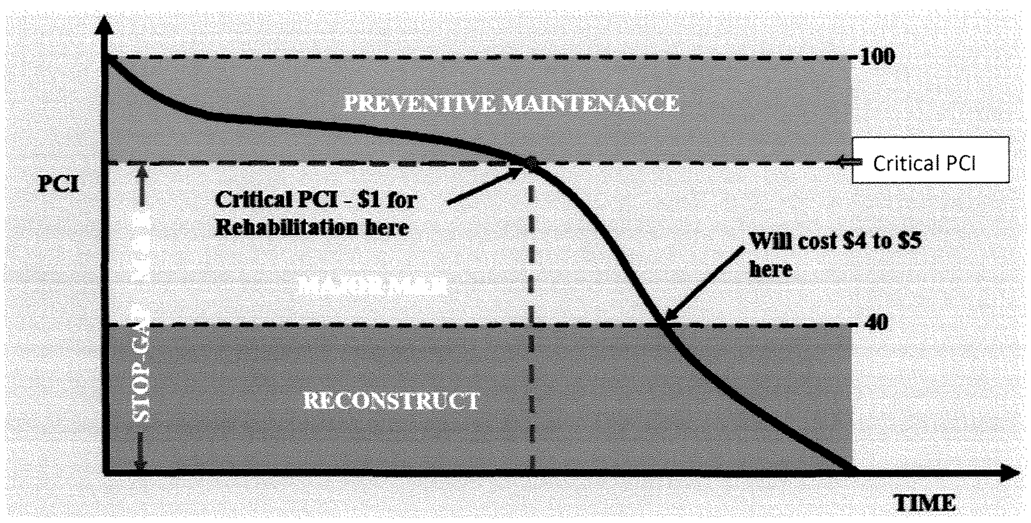



**Figure 3.9** – Schematic of Pavement Family Modeling and Critical PCI

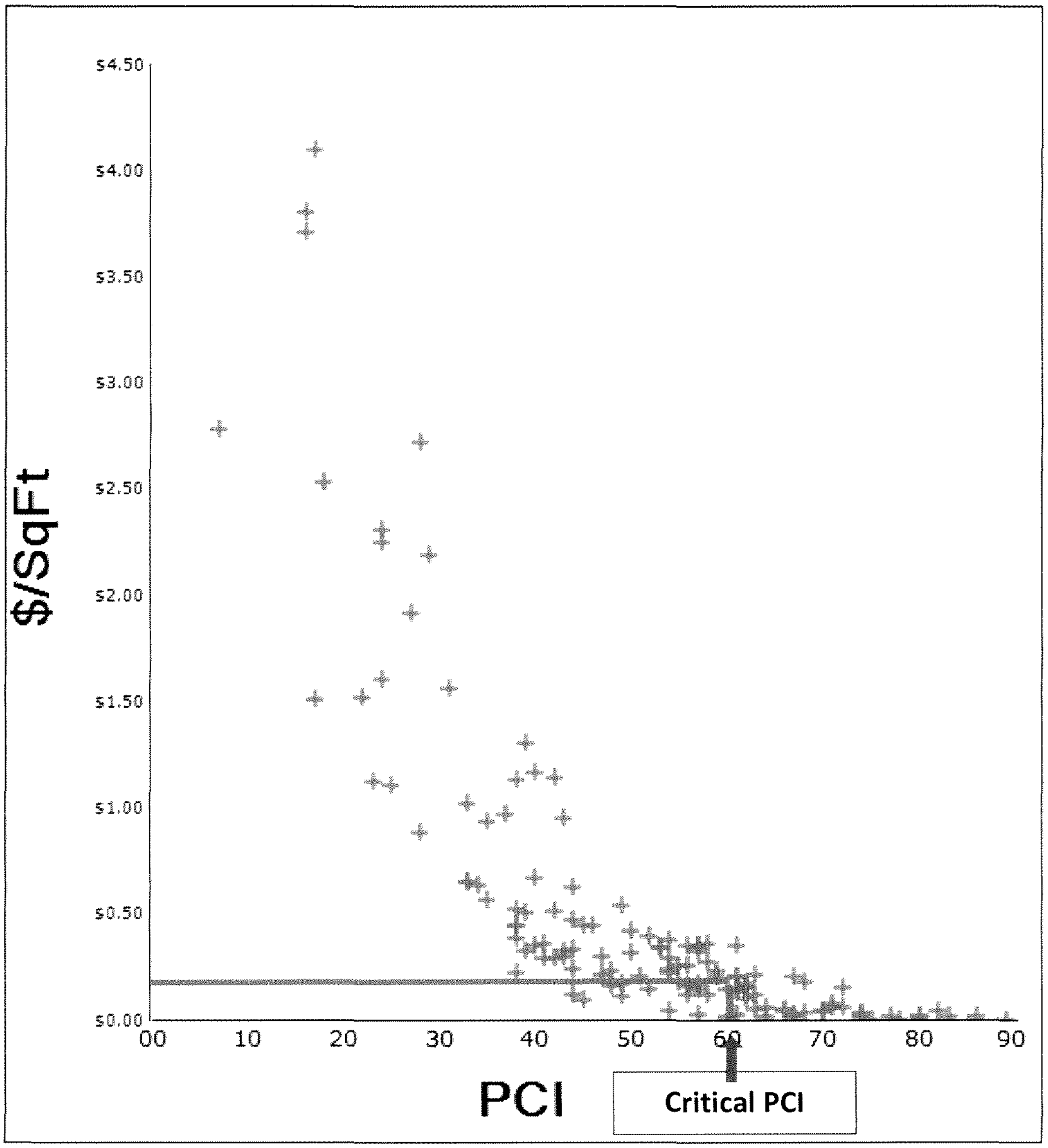


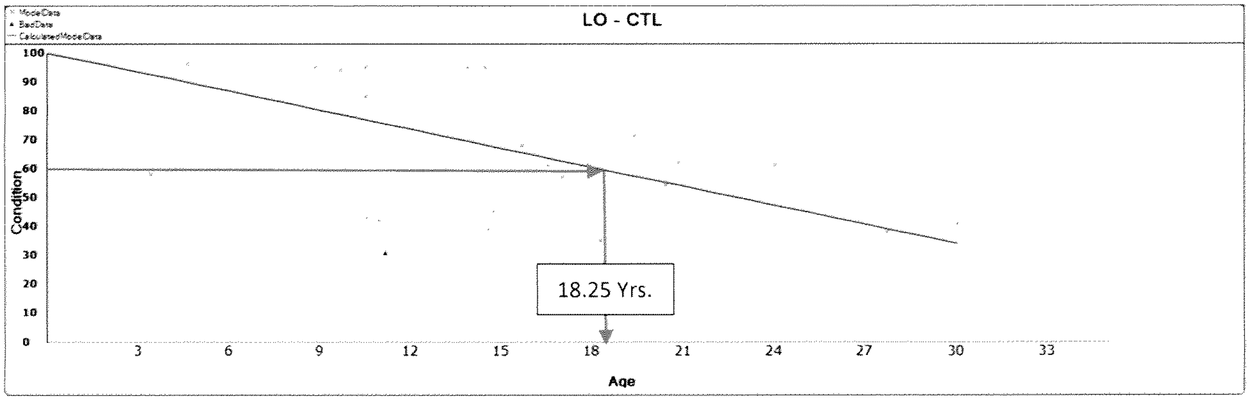

**Figure 3.10** – Increase in Pavement Area Unit Cost for Preventive Maintenance as Function of PCI using Data from All Sites

### e. PCI Deterioration Family Modeling

The PCI data of the surveyed sites were grouped into four families:

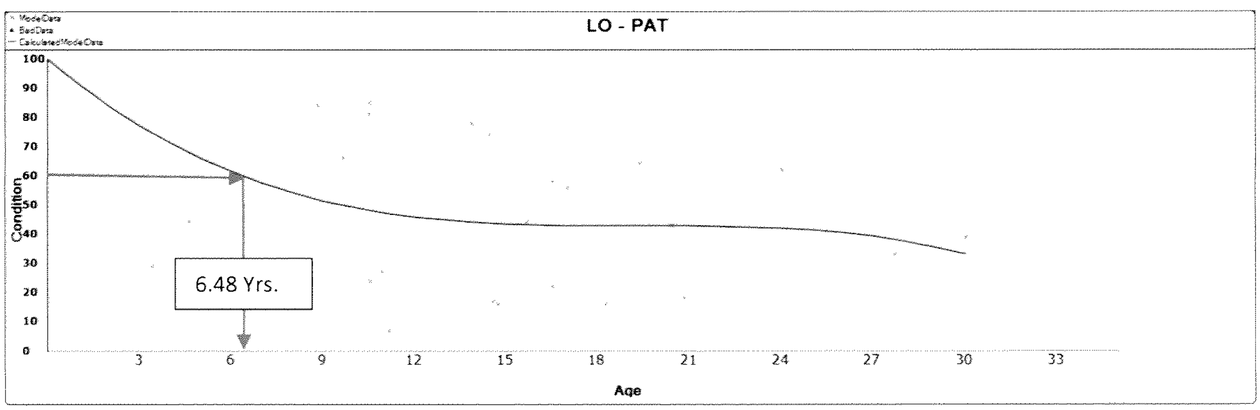
(1) Local Streets - Control Areas (LO - CTL)
(2) Local Streets - Patched Areas (LO - PAT)
(3) Select Streets - Control Areas (SE - CTL)
(4) Select Streets - Patched Areas (SE - PAT)

The PAVER pavement management system was used to develop the best fit PCI deterioration model for each of the families using the 95% envelope for identification of outliers. The models are presented in **Figures 3.11, 3.12, 3.13, and 3.14** respectively. Using a Critical PCI of 60, the functional age of each of the families was calculated and the results summarized in **Figure 3.15**. As seen in the figure, there is a significant loss in the pavement functional life exceeding 60% for both the Local and the Select streets. This is not surprising based on the results of the distress analysis presented earlier.



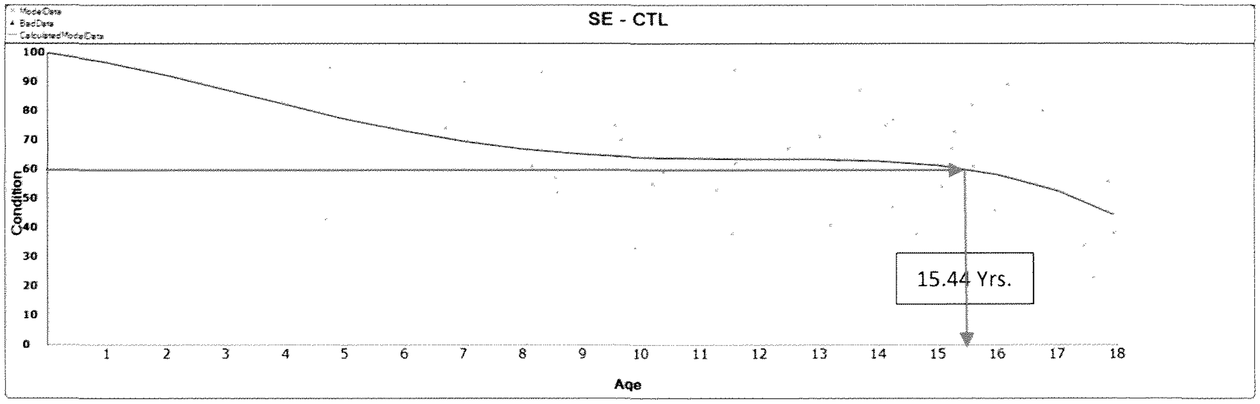

PCI = 100 - 2.19197535514832 X^1

**Figure 3.11** – PCI Deterioration Family Model for Local Control Inspection Units



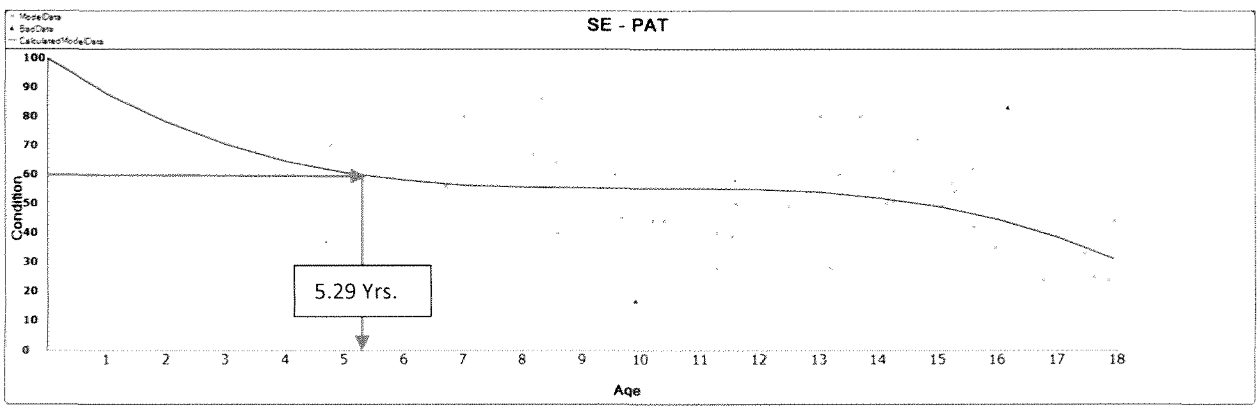

PCI = 100 - 8.86568164825439 X^1 + 0.458621650934219 X^2 - 0.00790794100612402 X^3

**Figure 3.12** – PCI Deterioration Family Model for Local Patched Inspection Units




PCI = 100 - 2.46104741096497 X^1 - 0.905964851379395 X^2 + 0.118088856339455 X^3 - 0.00387875293381512 X^4

**Figure 3.13** – PCI Deterioration Family Model for Select Control Inspection Units




PCI = 100 - 13.5504732131958 X^1 + 1.37279796600342 X^2 - 0.0463593378663063 X^3

**Figure 3.14** – PCI Deterioration Family Model for Select Patched Inspection Units

Functional (PCI) Useful Pavement Life
Critical PCI = 60

| | Control | Patch | Loss in Functional Life |
|---|---|---|---|
| **Local Roads** | 18.25 Yrs. | 6.48 Yrs. | 64% |
| **Select Roads** | 15.44 Yrs. | 5.29 Yrs. | 66% |

**Figure 3.15** – Comparison of Expected Pavement Functional Life of Control and Patched Pavements

## Chapter 4: Pavement Structural Condition Survey and Analysis

### a. Procedure:

Before testing the designated locations, the PCI surveyor determined two areas: The control area and the trench area that comprised the utility-trench. Each area was no less than 1500 $ft^2$ or more to meet ASTM PCI Standard D-6433. The control area did not have any trench inside of the determined area and was at least 10 ft. away from any other trench. The control area also met the following requirements:

1) All selected sections were flexible pavements (PCC pavements are excluded) and both areas (trench & control) consisted of the same pavement structure, same thickness, mix, and age.
2) Trench and control areas had the same traffic flow (same lane).
3) The control area was located as close as possible to the trench area and when it was viable the control area was located immediately adjacent to trench area.

Cores were obtained with the following criteria:

1) Pavement thickness was determined: i) In the trench, ii) Outside the trench, and iii) In the control area.
2) Cores in each site were located at equal distance from the curb face to ensure unbiased comparison.
3) The difference in total pavement thickness between the control and outside trench cores should be less than 1 in.
4) As many cores, as necessary (minimum 2 cores) were cut in the "Control FWD testing area" to verify thickness consistency.
5) The pavement structure was similar in both areas including base.

Falling Weight Deflectometer (FWD) criteria:

1) A minimum of eight deflections were measured adjacent to the joint around the trench (**Figure 4.1**). The measurements were obtained by positioning the FWD loading plate so that the edge of the plate was no more than 0.5 in. away from the

joint of the trench. It was noted that trench corners usually showed the highest deflection.

2) One additional deflection was measured in the center of the trench to evaluate the quality of the trench
3) Eight deflections were measured in the control area along the same line as the coring locations (**Figure 4.2**). The spacing between deflections depended on the size of the control area. Deflection readings were taken at equal distance apart on control pavement area that showed consistent pavement thickness with the tested trench area. If no consistency of thickness was established, the tested control area was discarded and relocated.

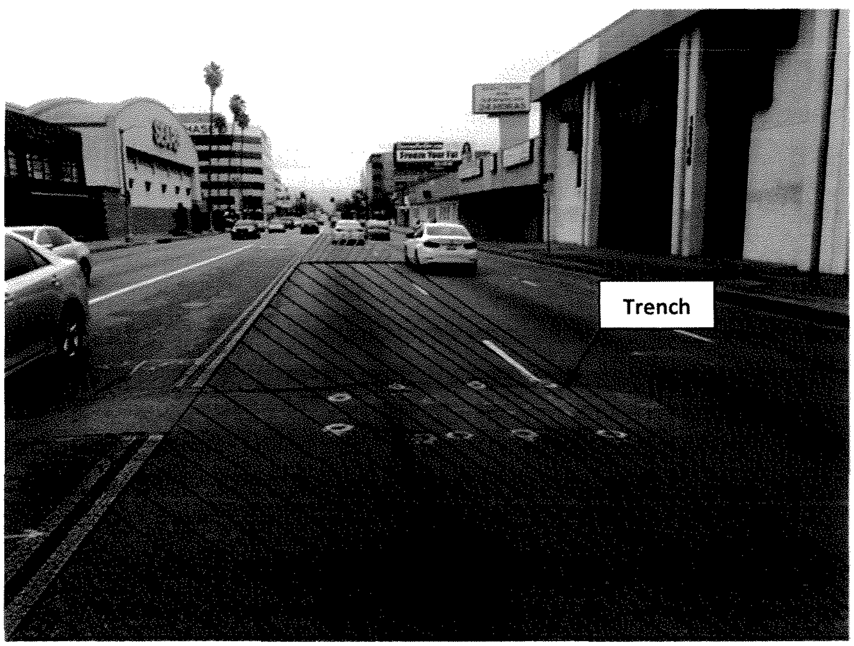



**Figure 4.1:** Shows both Trench and Control area (S37)

**Figure 4.2**: Shows FWD to be measured in a control area with consistent Asphalt thickness structure.

### b. Pavement Falling Weight Deflectometer (FWD) Testing

A total of 2323 pavement deflection tests were performed during the project. Pavement deflection is one of the required parameters necessary for pavement evaluation to determine the pavement structural capacity and to calculate the pavement and overlay design. Deflections, measured in thousandths of an inch (mils), were directly measured using a truck mounted Falling Weight Deflectometer.

A truck mounted Foundation Mechanics model Jils 20T Falling Weight Deflectometer (FWD) with an equivalent load of 9,000 pounds was used to measure the pavement surface deflections of the existing asphalt concrete pavements in the trench (patched) and control (non-patched) areas. The FWD is a load-deflection device that applies an impulse load by dropping a mass onto a circular load plate of 6 inches radius placed on the pavement surface to simulate a moving wheel load. This device uses deflection transducers that measure the resulting pavement deflections in the "deflection basin." One transducer is located at the center of the loading plate, with the remaining six transducers spaced at intervals of 8, 12, 18, 24, 36, and 60 inches from the center of the plate.

The FWD survey was performed by measuring nine (9) pavement deflections in each trench area (one inside the trench and eight at the outside edge of the trench) and eight (8) deflections in the corresponding control area. The pavement deflection measurements were determined in accordance with ASTM Designation: D 4695 – 03.

The measurements obtained are presented in **Appendix 4.A**. All deflection measurements were normalized to 9 kips and 68° F using AASHTO Guide for Design of Pavement Structures 1993, AC Temperature Adjustment Factor Table (AASHTO Manual - Figure 5.6, pg. III-99).

Accumulated deflection, $D_0$ (Normalized to 9 Kips and 68° F) of Local Sites and respective Controls clearly show higher accumulated deflection on trenches than controls. The values are 560 mils and 398 mils, correspondingly. The same observation is seen in Select Trenches vs. Controls where the values are 504 mils and 334 mils**,** respectively (**See Figure 4.3**). The average normalized deflection ($D_0$) of Local Trenches was 41% higher than their corresponding Control**.** The average normalized deflection ($D_0$) of Select Trenches was also 51% higher than their corresponding Control **(See Figure 4.4**). This shows that the pavement surrounding each trench has been weakened more than the rest of the pavement section, thereby accelerating pavement failure under traffic. It was also observed that the deflection ratio (around patch/ control) was higher among select streets than local streets.

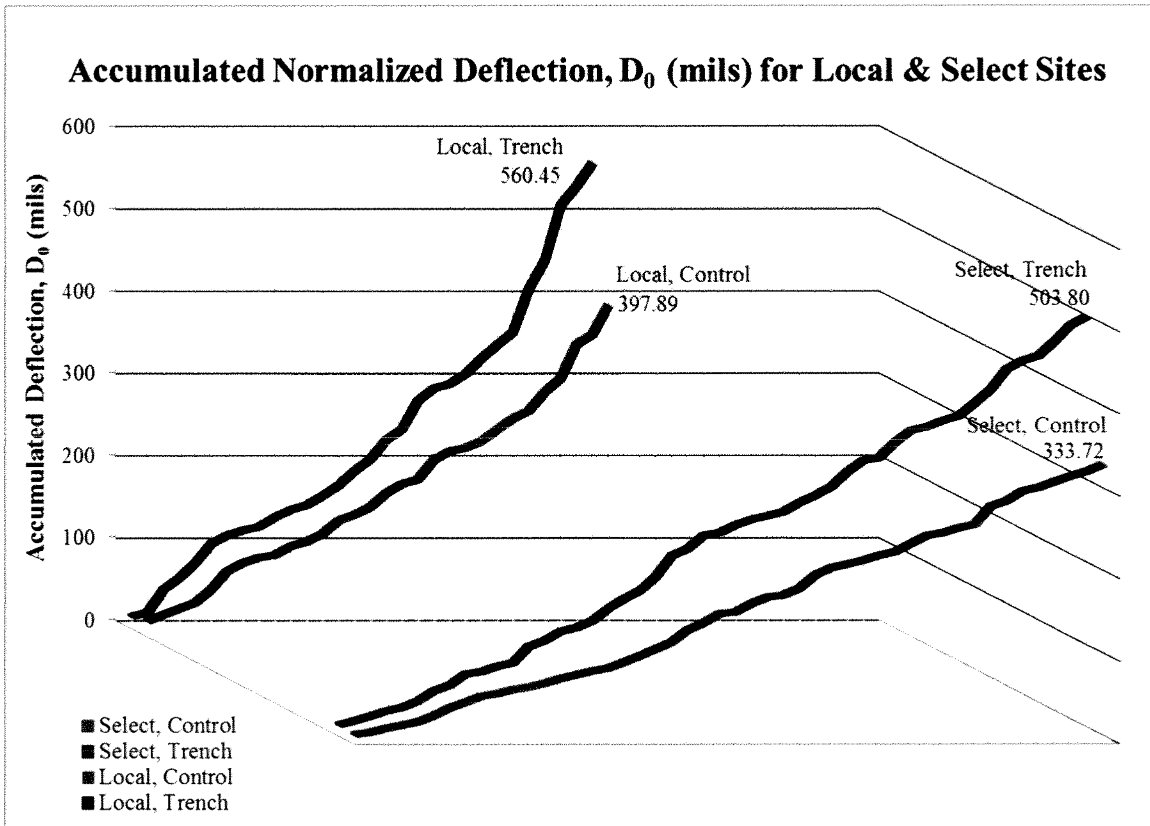



**Figure 4.3** – Comparison of Control and Trench (PAT) Accumulated Deflections

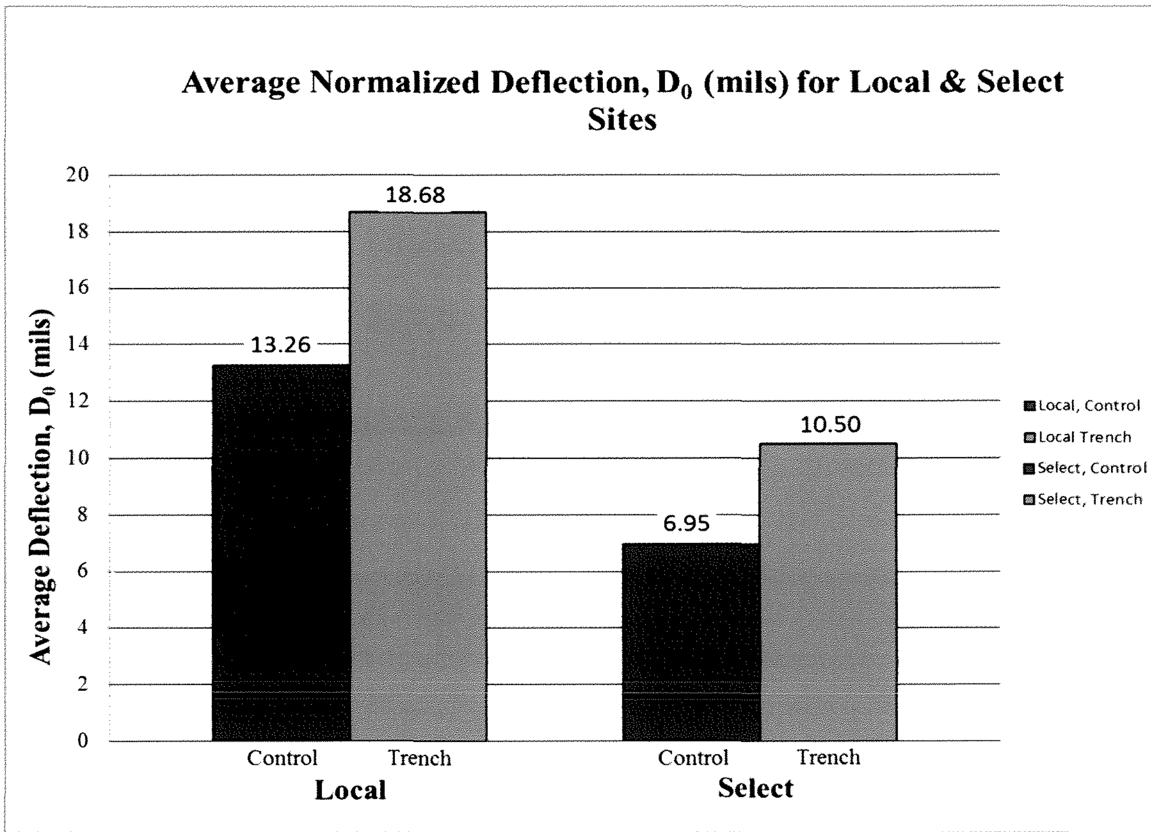



**Figure 4.4** – Comparison of Control and Trench (PAT) Average Deflections

A regression analysis was performed to determine the relationship between the average normalized deflections ($D_0$) of Local and Select trenches and their respective controls by means of a scatter plot (**See Figure 4.5**), then a straight line (the best fit of the regression line) that describes such relationship in the best possible manner was calculated and drawn with the Excel program.

The trend of the regression line clearly shows that the normalized deflections in the trench area are higher than the control area or that the trench area has been debilitated by the utility trench.

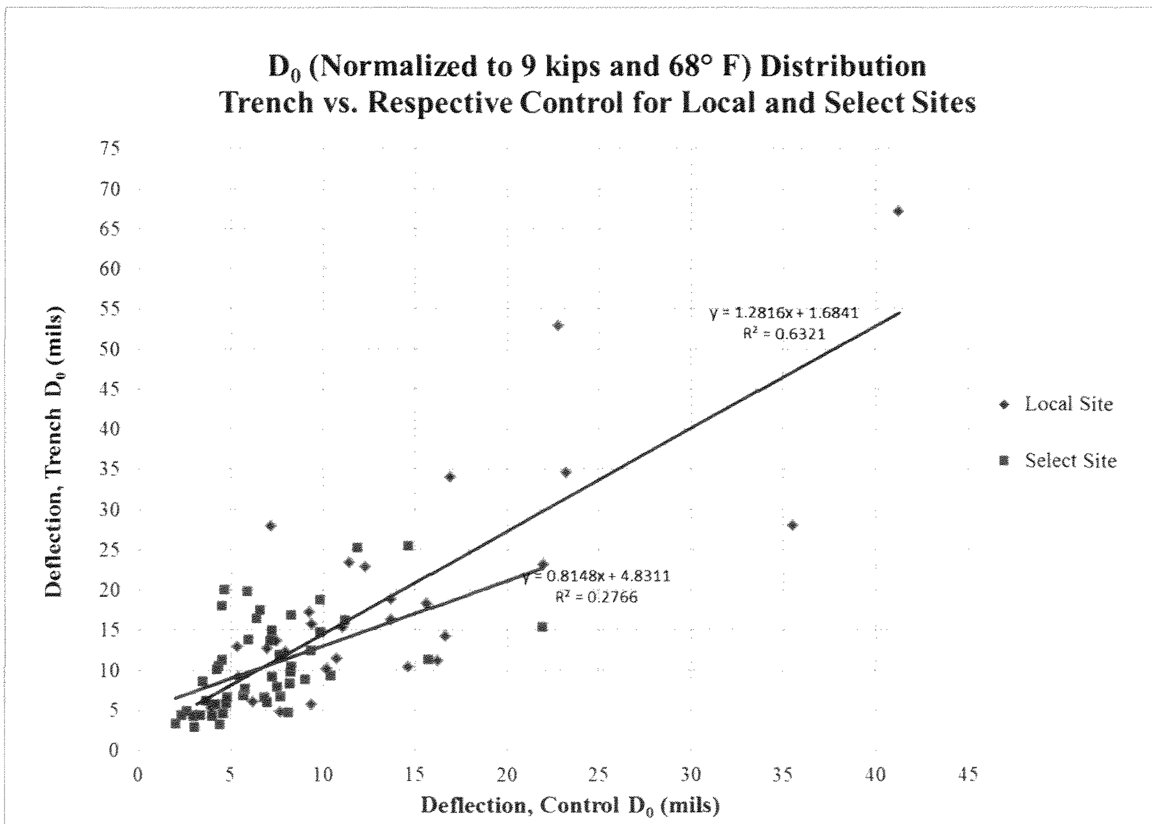



**Figure 4.5** - Comparison of Control and Trench (PAT) Deflections

c. **Existing Pavement Thickness (Coring)**

Existing structural pavement thickness was also determined to find out if utility trenches were properly overlaid to match the original pavement thickness structure and to calculate the overlay thickness design for both areas. The pavement thicknesses for each trench and respective control were determined by coring and are shown in **Appendices 4.B & 4.C.** A total of four-hundred-eighteen (418) cores were cut for this entire investigation. Pavement cores were cut using an Acker Model PT-22 truck-mounted core cutter with an eight-inch core bit and Geoprobe Model 6600.

Coring data shows that inside of trench (**Trench-In**) asphalt concrete thickness is much less than outside of the trench (**Trench-Out**) see **Figure 4.6.**

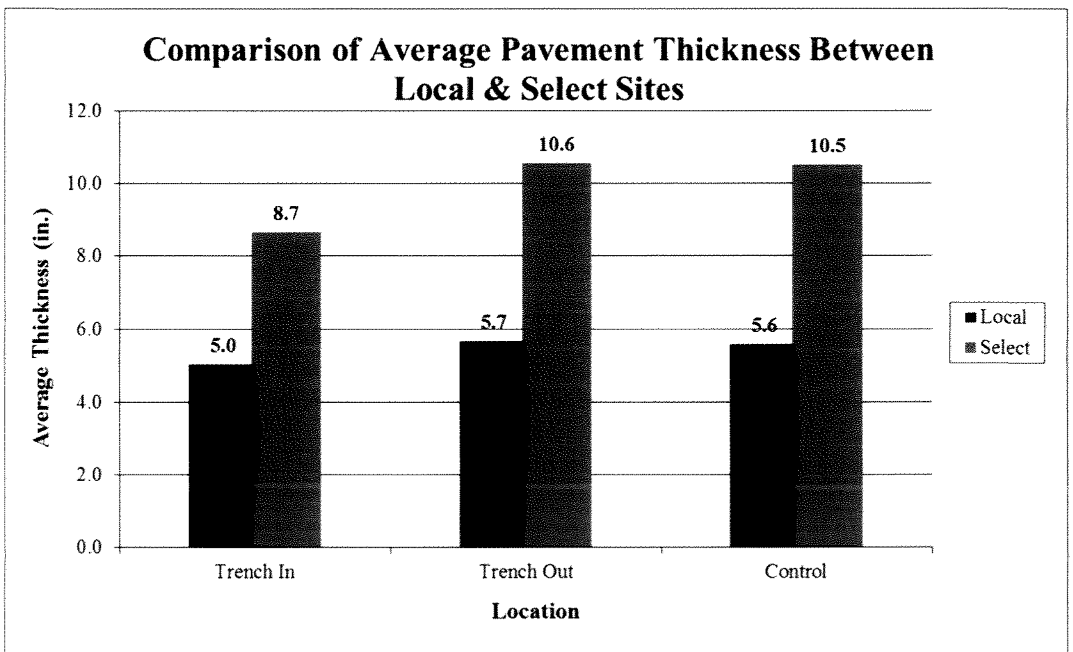



**Figure 4.6** – Average Pavement Thickness

The comparison of the average pavement thickness between Local and Select streets **(Figure 4.6)** demonstrates that in both classifications **(Local and Select)**, the pavement thickness inside of the trench **(Trench-In)** was less than outside (also near) the trench **(Trench-Out)** and its respective control. Furthermore, this difference is more significant among Select than Local streets. This is further illustrated in **Figures 4.7 and 4.8** showing a scatter plot between the Trench-out and Trench-in AC thickness for Local and Select sites. The figures show that most of the Select trenches and several of the Local trenches were not properly restored to match the original pavement AC thickness. **Figure 4.9** is a photo of the coring process.

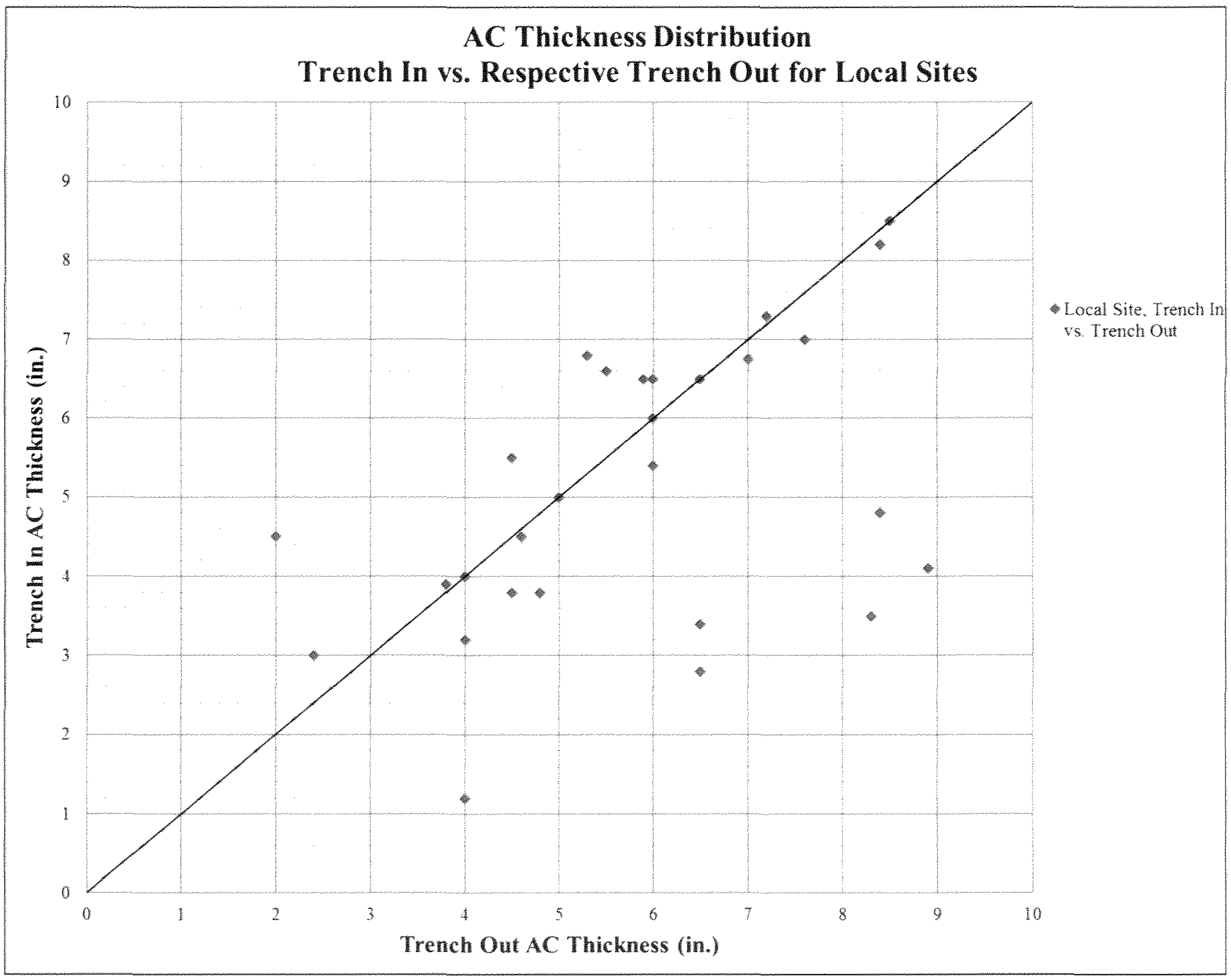



**Figure 4.7** – AC Thickness Comparison between Trench – in and Trench -out for Local Sites

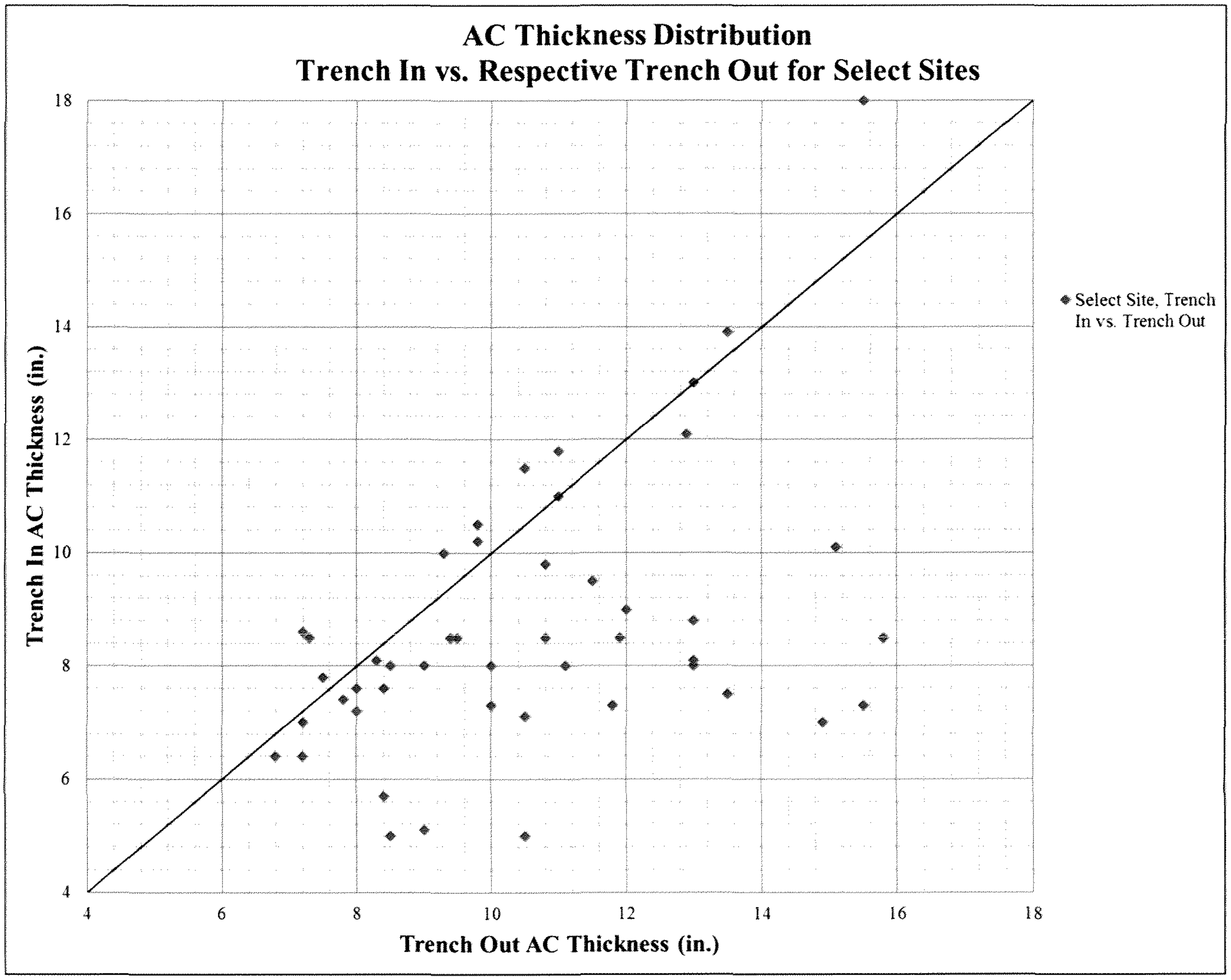



**Figure 4.8 -** AC Thickness Comparison between Trench – in and Trench -out for Select Sites


**Figure 4.9**: Existing pavement thickness determination Trench-in & Trench-out.

### d. Piezocone Penetration Testing

Two hundred- thirty- four (234) CPTU Piezocone Penetration Test soundings were performed and data was collected to a depth of two (2) feet unless refusal depth was reached **(See Appendix C)**. The CPTU soundings were conducted using a truck-mounted Geoprobe Model 6600 and a 20-ton capacity cone with a base area of 10 $cm^2$ and a friction sleeve of 150 $cm^2$ located above the Piezocone.

$N_{60}$ is a parameter classically determined from SPT blow counts and provides an indication of the relative density and strength of the soil. In this study, $N_{60}$ is a calculation resulting from pushing a Piezocone, or cone penetrometer with pore pressure measurement through the undisturbed soil underneath the pavement and recording data. A comparison average of $N_{60}$ values for Local and Select trenches and respective controls are presented in **Figure 4.10.**

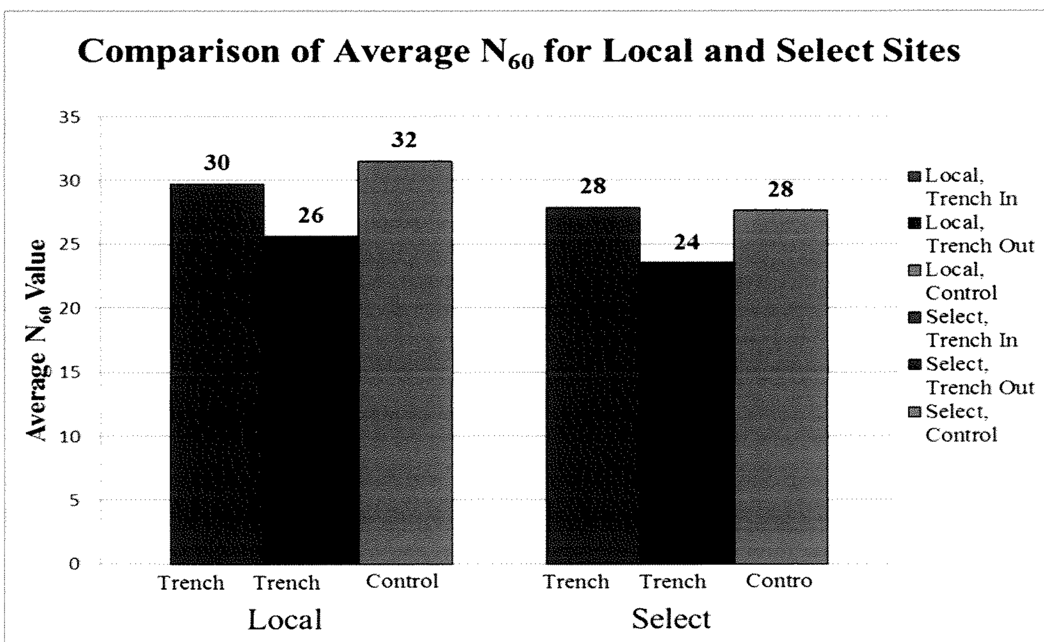



**Figure 4.10** – Comparison of relative Soil Strength

In this comparison, both classifications exhibit the Control $N_{60}$ values higher than the Trench-Out which indicates that the utility trench disturbed and debilitated the strength of the soil under the adjacent pavement. Furthermore, it was determined that 30% of Local and 25% of Select trenches were treated with liquefied soil cement slurry, consequently improving the average of the $N_{60}$ Trench-In values compared with their respective Controls.

Additional parameters in this dynamic procedure includes measurement of tip resistance (**qc**), sleeve friction (**fs**), and pore water pressure (**$U_2$**), These measurements determine soil stratigraphy and corrected SPT energy ratio $N_{60}$ values. This is all done by operating the computer programs CPT-log and CPT-pro. On a few occasions, the trench is backfilled with cemented sand, which is extremely hard. While we are unable to penetrate this layer with the cone, we were able to penetrate the subgrade below the outside edge of the trench. We found that $N_{60}$ values of the subgrade below the outside edge of the trench are lower than the $N_{60}$ values of the subgrade in the control. This means that the disturbance of the soil caused by the excavation of the trench has weakened the surrounding subgrade, which will cause premature failure of the pavement adjacent the trench.

The Piezocone takes measurements at 2 cm intervals of bearing resistance (**qc**), unit sleeve friction resistance (**fs**), and pore pressure behind cone (**$U_2$**). All CPTU soundings were performed in accordance to ASTM D-5778 Standard Test Method for Performing Electronic Friction Piezocone Penetration Testing of Soils.

All CPTU data was collected by a wireless CPTU cone (serial No. 4130, calibrated on 07/22/2016, traceable to NIST) manufactured by Geotech AB Company. Soil classification is based on **Rf** (friction ratio) and **qt** (corrected cone resistance), Robertson 1986, using CPT-pro software by Geosoft company.

The measurements that were obtained are presented in **Appendix 4.B**, with their corresponding graphical CPTU test results.

**Figure 4.11** is a summary of the percentages of different classification of soils encountered under pavement structures in both groups.

| Local Streets | | | | | | |
|---|---|---|---|---|---|---|
| Classification | Sand | Silty-Sand | Sandy-Silt | Clayey-Silt | Sensitive Fine-Grained | Total |
| Sites | 8 | 5 | 4 | 2 | 11 | 30 |
| Percentage | 27 | 17 | 13 | 7 | 37 | 100 |
| **Select Streets** | | | | | | |
| Classification | Sand | Silty-Sand | Sandy-Silt | Clayey-Silt | Sensitive Fine-Grained | Total |
| Sites | 15 | 14 | 9 | 0 | 10 | 48 |
| Percentage | 31 | 29 | 19 | 0 | 21 | 100 |

**Figure 4.11 -** Percentages of Different Classification of Soils

### e. Overlay Thickness Designs Required

A total of one-hundred-fifty-six (156) overlay thickness designs and (156) Flexible Pavement designs were calculated. Overlay thickness design is the required addition of compacted Hot Mix Asphalt (HMA) to an existing pavement to sustain predicted repeated structural loading from traffic over the design life of the pavement.

The overlay and pavement designs were determined utilizing the 1993 AASHTO Guide for Design of Pavement Structures, **AASHTOWare DARWin 3.1 Pavement Design, Analysis & Rehabilitation for Windows computer software**. The results are provided in **Appendix 4.C**. The average mid-depth temperature was calculated based on **BELLS3** (Routine testing methods), **LTPP Guide to Asphalt Temperature Prediction and Correction, Publication Number: FHWA-RD-98-085.**

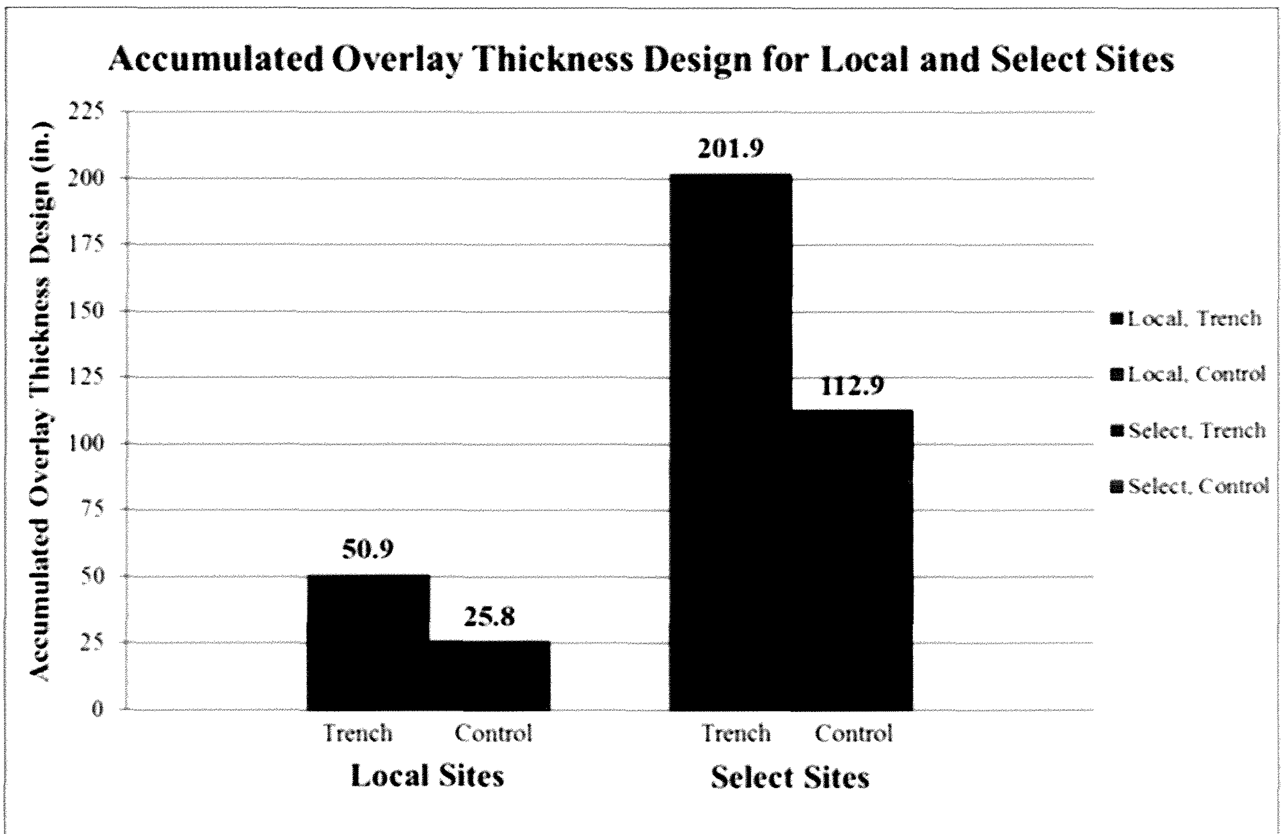



**Figure 4.12** – Comparison of Accumulated Required Overlay Thicknesses

The accumulated overlay thickness design, in inches, for Local and Select trenches and their respective control areas are presented in **Figure 4.12**. In both street classifications, the accumulated required thickness design is significantly higher in the Trench area than the Control area (98% higher for Local & 79% higher for Select).

In addition, the average overlay thickness design has also been calculated to illustrate how the weakness inflicted in the pavement by the utility trench must be restored with "additional thickness structure" to meet traffic demands when compared with the control average overlay thickness design required to meet such demands (**see Figure 4.13**). Using this figure, it was concluded that the Local trench areas require an average of **0.84** inches more structure than its respective control and an average of **1.86** inches more structure is required for the Select trench area than its respective control. This means that the trench's surrounding pavement has been negatively affected by the excavation of the trench, and the effects are very significant and costly to remediate the damage caused by the trench to bring the structure back to its original capacity.

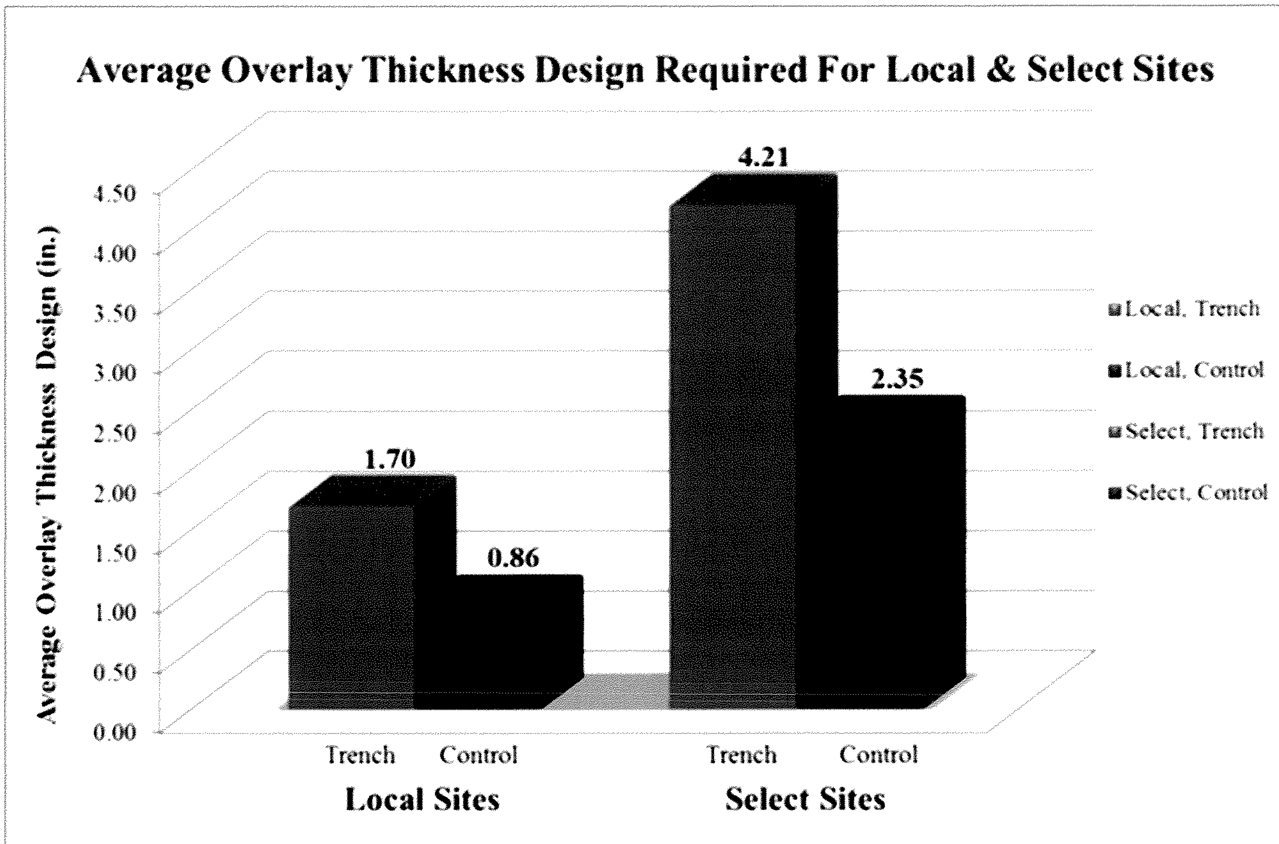



**Figure 4.13** – Comparison of Average Required Overlay Thicknesses

## f. Pavement Structural Life

The FWD data collected from all control and utility cut trench/patch areas were previously used by the City of Los Angeles to determine section/location specific overlay thickness requirements based on projected traffic (10-yr ESALs) and back-calculated subgrade resilient modulus ($M_R$). Overlay thicknesses were then determined based on the AASHTO structural deficiency approach, whereby the structural capacity of the existing pavement, in terms of the back-calculated effective structural number ($SN_{EFF}$) is compared to the required structural number ($SN_{REQ}$) to support the 10-year traffic projections. Where the $SN_{REQ}$ exceeds $SN_{EFF}$, the hot mix asphalt (HMA) overlay thickness ($T_{OL}$) is calculated as:

$$T_{OL} = (SN_{REQ} - SN_{EFF}) / a_i \qquad \text{Eqn. 1}$$

where:

$T_{OL}$ = HMA overlay thickness requirement, inches
$SN_{REQ}$ = Required structural number to support future 10-year traffic
$SN_{EFF}$ = Back-calculated structural number of existing pavement
$a_i$ = structural coefficient for HMA materials ($a_i$ = 0.44 used in analysis)

Where $SN_{EFF}$ values exceed $SN_{REQ}$, no overlay is deemed necessary ($T_{OL}$ = 0).

The impacts of utility cut trenching/patching on post-overlay service life were computed based on the consideration that the actual constructed overlay thickness would equal that determined for the comparable control sections using Eqn. 1 above. Using this overlay thickness in conjunction with the subgrade resilient modulus and $SN_{EFF}$ values back-calculated for the utility cut trench areas, the allowable ESALs were computed using the standard AASHTO design equation as follows:

$$\log_{10}(W_{18}) = Z_R \times S_o + 9.36 \times \log_{10}(SN+1) - 0.20 + \frac{\log_{10}\left[\frac{\Delta PSI}{4.5-1.5}\right]}{0.40 + \frac{1094}{(SN+1)^{5.19}}} + 2.32 \times \log_{10}(M_R) - 8.07 \qquad \text{Eqn. 2}$$

where:

$W_{18\text{-}ALL}$ = Allowable 18-kip equivalent single axle loadings (ESALs)
$Z_R$ = Standard normal deviate associated with design level of reliability
$S_O$ = Overall standard deviation (SO = 0.49 used in analysis)
SN = Post-overlay structural number of the trench section (i.e., $SN_{(EFF+OL)}$)
$\Delta$PSI = Loss of Serviceability due to traffic
$M_R$ = Subgrade resilient modulus, psi

The $W_{18\text{-}ALL}$ values, computed using Eqn. 2 above, were compared to the design ESALs ($W_{18\text{-}DES}$) previously used by the City of Los Angeles to determine $SN_{REQ}$ and $T_{OL}$ values for the control section. For segments with $W_{18\text{-}ALL}$ less than $W_{18\text{-}DES}$, the pavement in the vicinity of the utility cut trench/patch would be expected have poorer performance than the control area and would reach terminal serviceability prior to the 10-year design period, thus shortening the life of the overlay and increasing the repair costs to the City.

Life Ratio Calculations:

The life ratio for the utility cut Patch sites compared to Control is hereby defined and computed as the ratio of $W_{18\text{-}ALL}$ to $W_{18\text{-}DES}$ as follows:

$$LR_{UTP} = W_{18\text{-}ALL} / W_{18\text{-}DES} \qquad \text{Eqn. 3}$$

where:

$LR_{UTP}$ = Utility Cut Trench/Control Life Ratio
$W_{18\text{-}ALL}$ = Allowable 18-kip ESALs within the utility cut trench/patch areas using $T_{OL}$ for control areas
$W_{18\text{-}DES}$ = Allowable 18-kip ESALs within the control areas using $T_{OL}$ for control areas

For some segments, the $W_{18\text{-}ALL}$ is greater than $W_{18\text{-}DES}$, indicating the pavement around the utility cut trench/patch would be expected to outperform the corresponding control section, in that case, the $LR_{UTP}$ set equal to 1.

**Appendix 4.D** provides listings of the calculated $LR_{UTP}$ values for the Select and Local segments included in this study. **Figure 4.14** provides a summary of the results.

| | Mean Life Ratio | Loss in Structural Life |
|---|---|---|
| **local Streets** | **0.45** | **55%** |
| **Select Streets** | **0.47** | **53%** |

**Figure 4.14** – Loss in Structural Life for Local and Select streets due to Utility Cut Patching

## g. Utility Cut Patching Width of Influence

Several trenches were also tested to determine utility cuts width of influence. Starting at the edge of each trench, deflections were measured, perpendicular to the utility cut joint, one foot apart, moving away from the joint until the change in deflection from the previous deflection reached near-zero (**Figure 4.15**). The purpose of this testing was to determine the distance away from each trench where the deflection was not affected by the utility cut. The distance from the edge of the trench to where change in deflection is near-zero is called the Width of Influence. **Figure 4.16**, is example results from two of the trenches. Figure 4.17, is a summary of the results from all 15 Local and Select tested trenches. The detailed results are provided in **Appendix 4.E.**

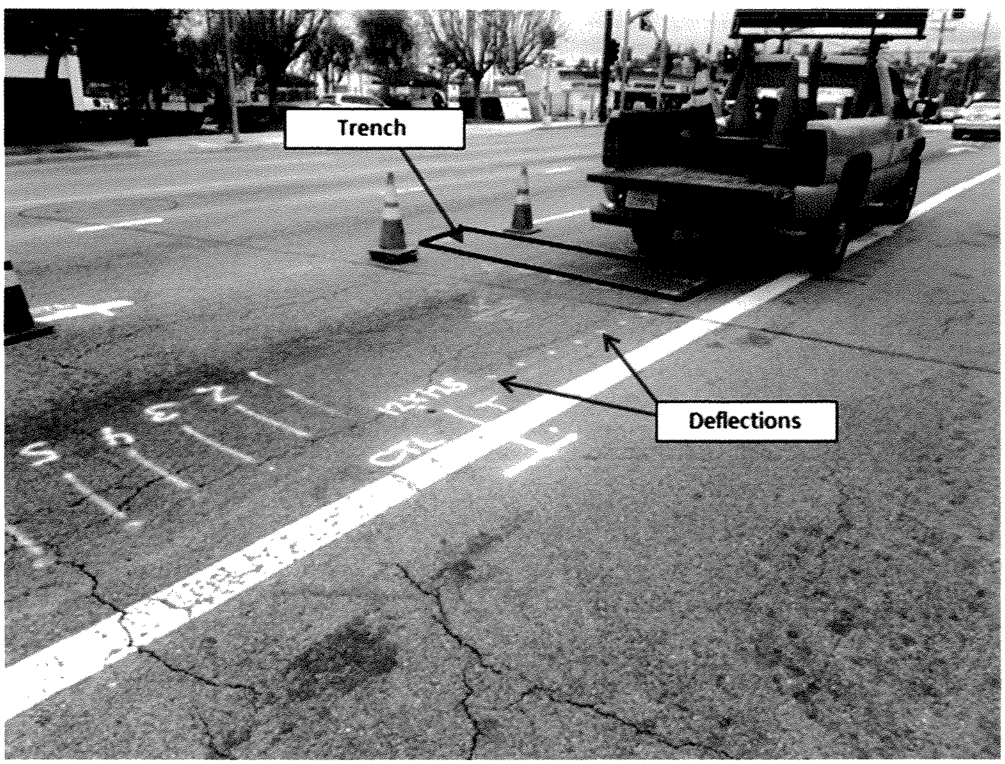



**Figure 4.15** - Width of Influence Testing

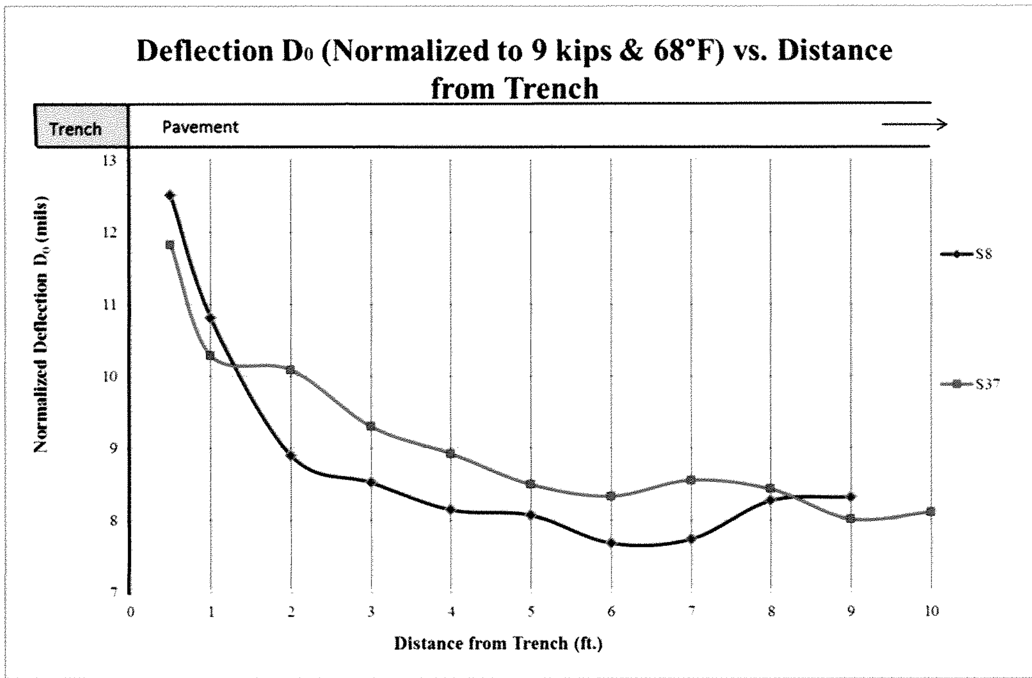



**Figure 4.16** – Example Width of Influence Testing for two Select Trenches (S8 and S37)

| Site | Patch # | Edge Deflection | Deflection at width | Deflection Range | Deflection Ratio | Width of Influence, ft. |
|---|---|---|---|---|---|---|
| Local | L18 | 18.14 | 13.39 | 4.75 | 1.35 | 7.00 |
| Local | L19 | 19.49 | 11.62 | 7.87 | 1.68 | 6.00 |
| Local | L24 | 28.51 | 14.49 | 14.02 | 1.97 | 4.00 |
| Local | L27 | 21.49 | 15.7 | 5.79 | 1.37 | 2.50 |
| Local | L28b | 35.94 | 28.49 | 7.45 | 1.26 | 6.00 |
| Local | L37 North | 26.44 | 19.58 | 6.86 | 1.35 | 5.00 |
| Local | L37 South | 37.13 | 20.81 | 16.32 | 1.78 | 4.00 |
| Select | S8 | 12.51 | 8.14 | 4.37 | 1.54 | 4.00 |
| Select | S23 | 20.1 | 7.33 | 12.77 | 2.74 | 10.00 |
| Select | S35 | 13.08 | 9.2 | 3.88 | 1.42 | 2.50 |
| Select | S37 | 11.82 | 8.49 | 3.33 | 1.39 | 5.00 |
| Select | S38 | 19.38 | 15.49 | 3.89 | 1.25 | 4.00 |
| Select | S40 | 15.58 | 9.67 | 5.91 | 1.61 | 7.00 |
| Select | S74 | 11.53 | 6.86 | 4.67 | 1.68 | 7.00 |
| Select | S77 | 13.5 | 8.98 | 4.52 | 1.50 | 3.50 |

**Figure 4.17** – Results of tested Utility Cut Width of Influence Testing

The following observations can be made from the results:

1. The deflection ratio around the edge of the patch compared to away from the patch ranges from 1.25 to 2.74 with an average of 1.59.
2. The Utility Cut Patch Width of influence ranges from 2.5 ft. to 10.0 ft. with an average of 5.2 ft.

   The results clearly show that utility cut patching weakens the surrounding pavement structure and thus the shorter functional life as well as the need for a thicker overlay thickness at the time of rehabilitation. The weakening of the pavement structure can also be compounded when the influence of two utility cut patches intersects as illustrated conceptually in **Figure 4.18**.

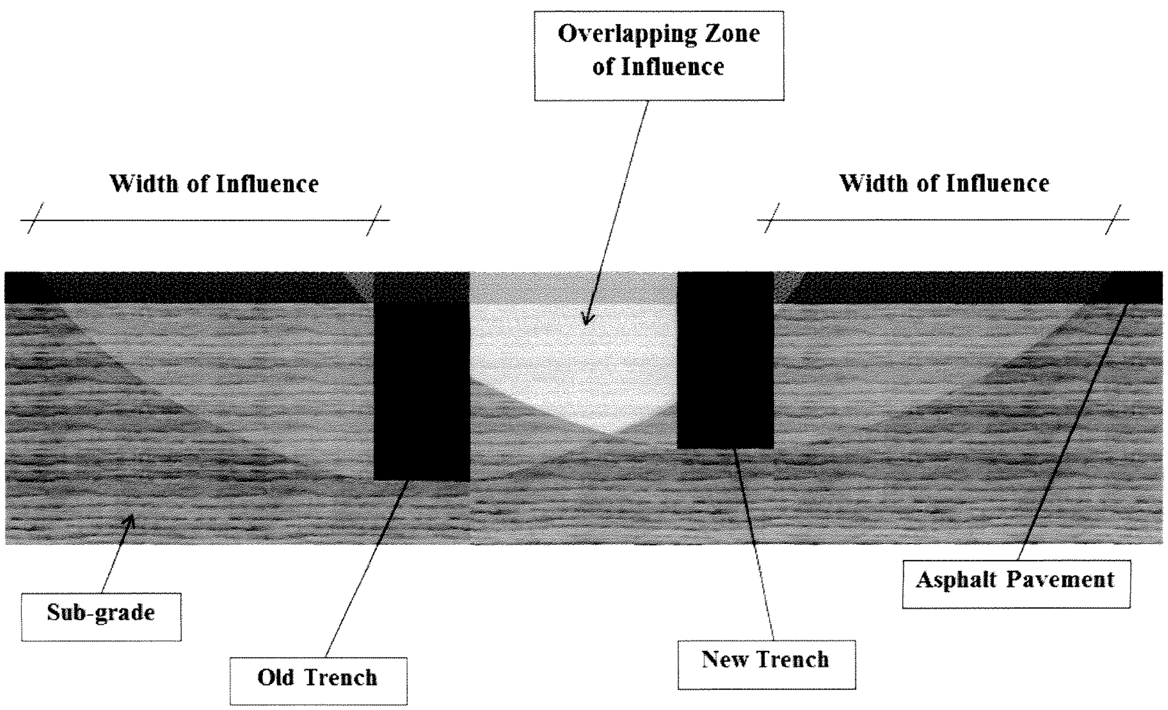



**Figure 4.18 -** Sketch of Overlapping Width of Influence under pavement.

## Chapter 5: Summary and Conclusions

The study determined the effect of utility cut patching on pavement functional life, pavement structural life, and the incurred extra pavement rehabilitation cost to the City of Los Angeles. A total of 78 pavement sites (30 Local and 48 Select) were evaluated. Each site had a patched area with an adjacent non-patched area that served as the control. All sites were flexible (asphalt) pavements.

Each site was tested in detail to compare the functional performance and structural condition of both the patched and control areas. The pavement functional performance was conducted using the Pavement Condition Index (PCI) method, ASTM Standard D-6433, and the City PAVER pavement management system database. The pavement structural condition testing was conducted using the Falling Weight Deflectometer (FWD), pavement coring, and Piezocone Penetration. Following is a summary of the evaluation results:

1. The PCI of the Control (Non-patched) is about 15 points higher than the Patched areas in Local sites. Similarly, the PCI of the Control (Non-patched) is about 11 points higher than the Patched areas in Select sites. **Figure 3.2.**
2. There is a higher percent of load related distresses (Alligator cracking and Rutting) in Patched areas vs. Control **(Figures 3.5 and 3.6.).** Most of the distress percentages are at the medium and high severity levels of the distresses **(Figures 3.7 and 3.8).**
3. There is a significant loss in the functional life of the Patched vs. Control. The loss was estimated as 64% for Local sites and 66% for Select sites. **Figure3.15.**
4. The average deflection around the patches is significantly higher than the Control**.** **Figure 4.4.**
5. The weakened width around the patch (measured perpendicular to patch joint) varies from 2.5ft to 10ft. with an average of 5.2 ft. The deflection ratio around the edge of the patch compared to away from the patch ranges from 1.25 to 2.74 with an average of 1.59. **Figure 4.17**.
6. The loss in structural life was estimated at 55% for Local sites and 53% for Select sites. **Figure 4.15.**
7. The average overlay design thickness for Patch is about twice as much as that needed for the Control. **Figure 4.13.**

8. The average pavement thickness of the trench is lower than around the trench and the control area. **Figure 4.6.**

Based on all the tests and analysis performed in this study, it is evident that there is significant damage inflicted by utility trenches to the adjacent pavement structures and underlying subgrade. Regardless of the age of the asphalt concrete pavement, the degrading of the pavement structure around the utility cuts remains significant. Consequently, the overlay thickness design to overcome the weakening of the pavement structure practically doubled the overlay thickness design required on the non-patched area as intended for future traffic in the same section.

Furthermore, the study indicated that utility trenches were not properly restored to match the original pavement condition. It is also evident that the damage and the repairs on higher traffic streets **(Select)** due to utility trenches are higher and therefore, costlier than low traffic streets **(Local)**.