

# Emerging Concrete Pavement Solutions

## Roller Compacted Concrete (RCC)



**Presented to:**

**APWA Nor Cal**

**November 3<sup>rd</sup>, 2016**

**Presenters:**

**Jason Shykowski, P.E., T.E. – City of Roseville**

**Debbie Haldeman – RCC Council**

**Clay Slocum, P.E. – CNCA**



# Outline:

- Definition / History
- RCC introduction
  - Material
  - Construction
  - QA/QC
- Jointing, Preserving & Utilities!
- Roseville's story
- Takeaways



Bellefontaine, Ohio – 125 Year Old Concrete Pavement



Photo: roadsideamerica.com

# Definition

**“Roller-Compacted Concrete (RCC) is a no-slump concrete that is compacted by vibratory rollers”**

- Zero slump (consistency of damp dense gravel)
- No forms or finishing
- No reinforcing steel
- High production
- Asphalt paving equipment



**Concrete placed in a different way!**



1930s:  
A form of RCC paving is performed in Sweden.



1970s:  
RCC pavements become common for log-sorting yards in Canada.



Late 1980s–early 1990s:  
RCC pavements are constructed for automotive, port, and intermodal facilities in the U.S.

## History of RCC

Early 1940s:  
The first RCC pavement in North America is an airport runway constructed in Yakima, Washington.



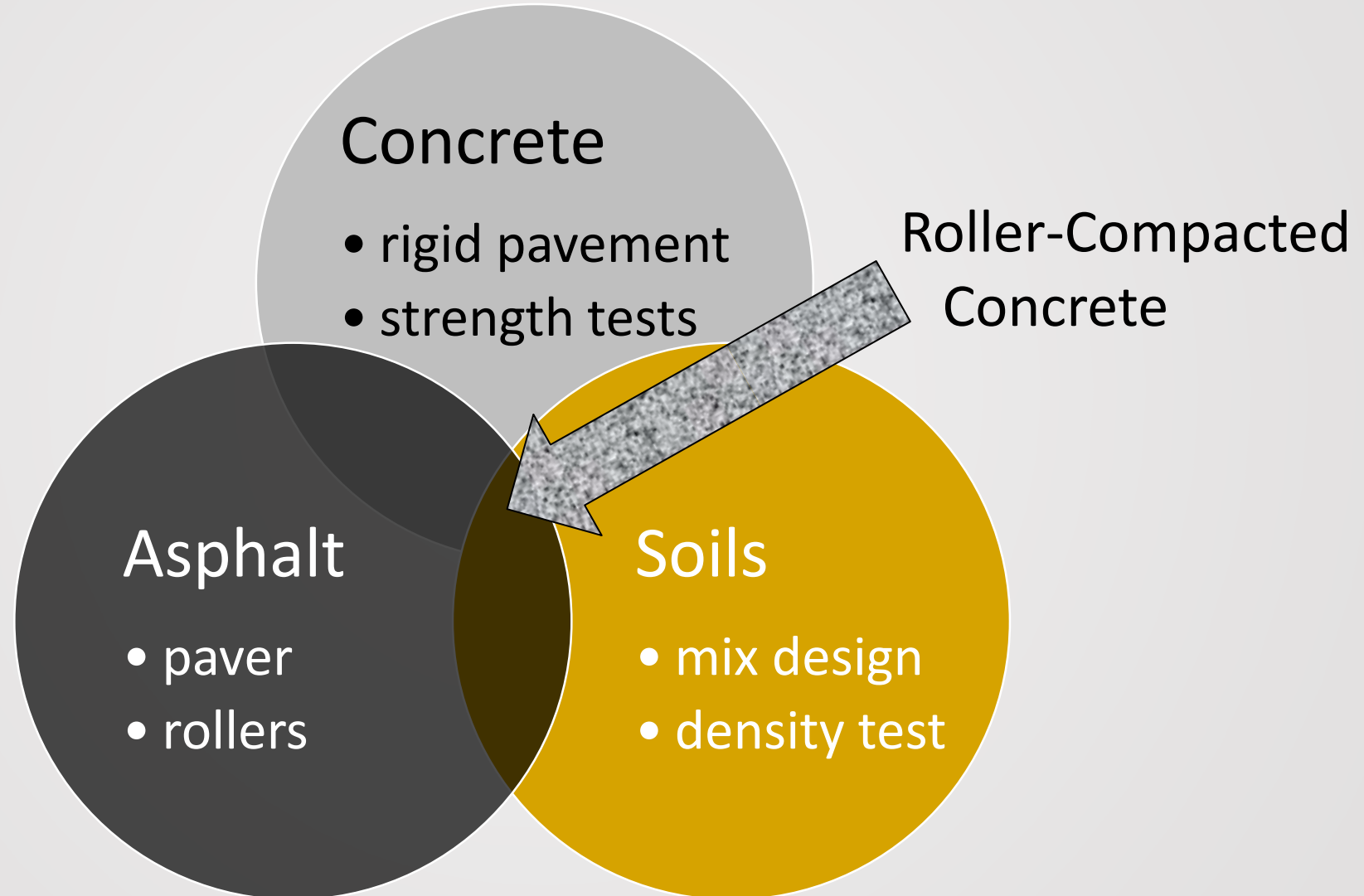
Early 1980s:  
US Army Corps of Engineers begins researching and constructing RCC pavements at military facilities in the U.S.



2000s:  
RCC pavements gain popularity for constructing low- to moderate-traffic streets and secondary highways.

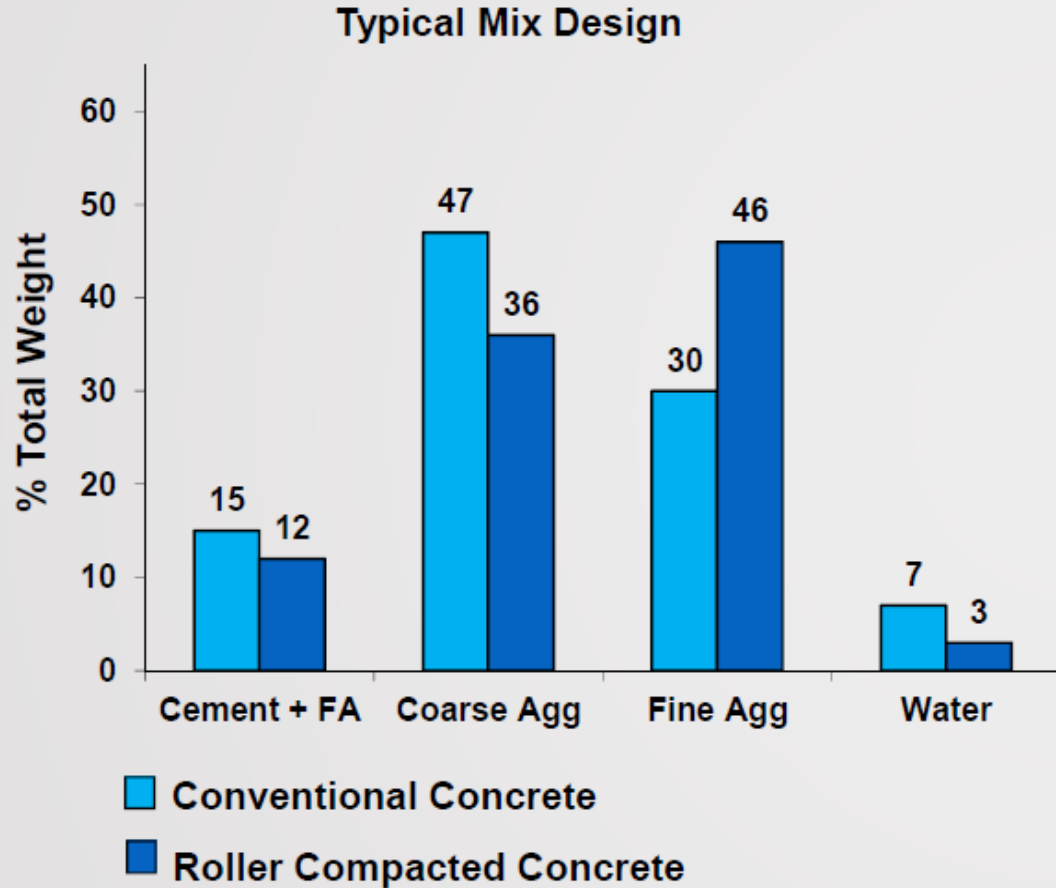


# RCC's Multiple Personalities



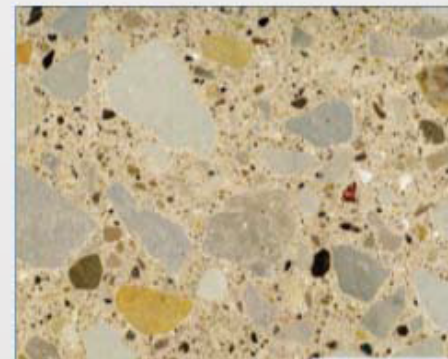
# RCC Mix Design Vs. Traditional

Achieves Similar or Better Engineering Properties Than Conventional Concrete



Typical Engineering Properties	Conventional (psi)	RCC (psi)
Compressive Strength	3,000 - 5,000	4,000 - 10,000
Flexural Strength (MOR)	500 - 700	500 - 1,000
Elastic Modulus	3.0 - 5.0 million	3.0 - 5.5 million

Conventional Concrete



RCC



# RCC Placing Equipment

## High Density Pavers

- High initial density, 90-100%
  - Compact to 98% avg. relative density with rollers
- Less roll-down
- 4" to 10" lift thickness range
- High-volume placement (5-7 ft/min)



# Recommended Batching System - A Continuous Pugmill Mixer



## Pugmill Production

- 200 ft by 200 ft staging area required
- High production rates: 50 to 200+ CY/hr
- Excellent mixing efficiency



# QA / QC Process

## Moisture & Density

- Tested with a nuke gage at depth
- Test density behind paver & after roller
  - Establish rolling patterns



## Compressive Strength

- Cylinders prepared with vibratory hammer according to ASTM C1435
- Cores can be obtained to verify density



# Curing & Saw Cutting Improves Performance

## Curing

- Ensure uniformity
- Apply as soon as possible
- Improves surface durability



## Saw Cut & Fill Joints (Where Necessary)

- More aesthetically pleasing
- Recommend sawing within 2 - 6 hours
- Spacing: Max 36 times thickness



# What Does RCC Look Like?



Diamon  
Conv  
Cor

# Diamond Grinding

## Diamond Grinding

- Removal of thin surface layer of hardened PCC
- Preserves pavement – smoothens the road
- Typical cost = \$3 to \$5 per square yard



## Benefits

- Typical 10-15 year rehab schedule
- Improves friction and surface aesthetics
- Reduces noise



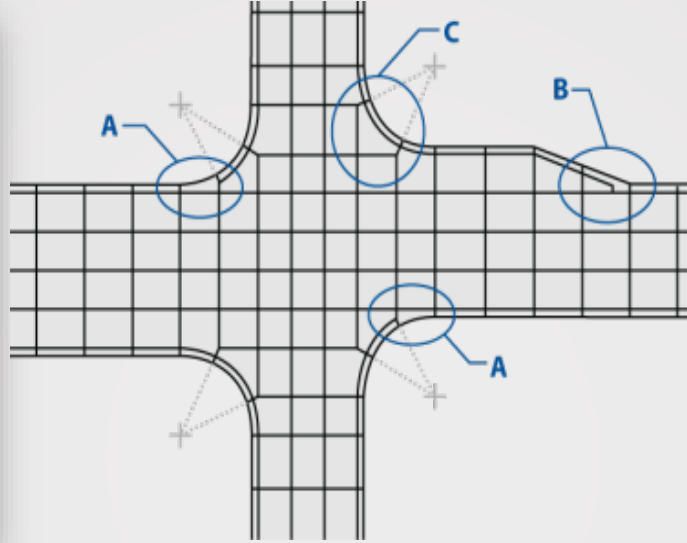
# Joint Layout Is Crucial To Performance

## BAD Jointing Practices



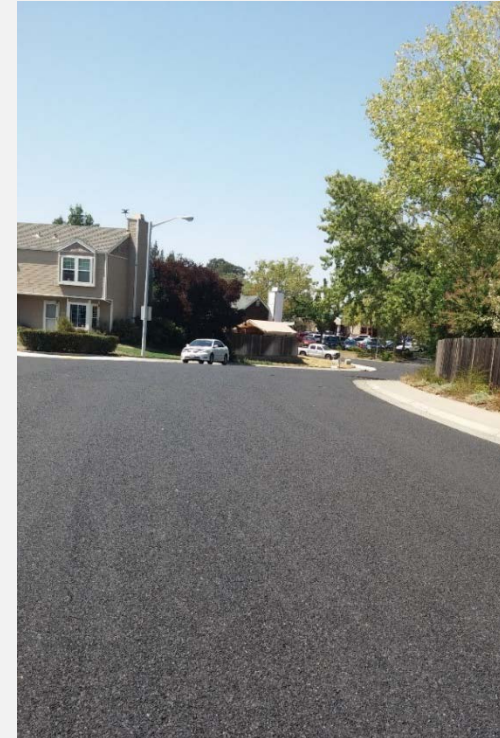
# Joint Layout Is Crucial To Performance

## Good Jointing Practices

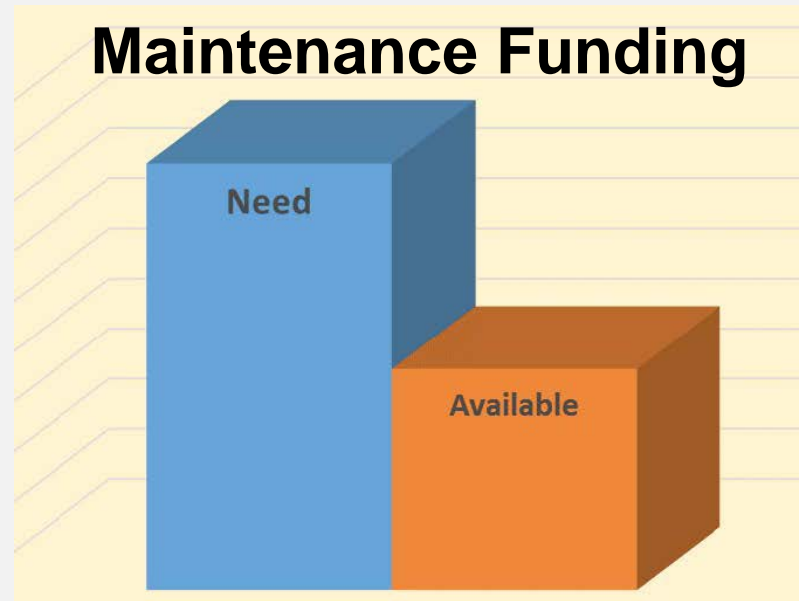


# Roseville's Challenge

- Street maintenance funding is a challenge
- Roseville's Funding sources:
  - State Gas Tax ← Largest
  - Utility Impact Reimbursements
  - Transportation Development Act
  - Federal Gas Tax
- State Gas Tax distributed by lane miles and population
- Gas Tax unchanged since 1993 while costs have tripled



# Roseville's Challenge



- Roseville – 1,000 lane miles of asphalt roadway
- Need to maintain 100 lane miles/year – \$8.5 million
- City averages \$4.4 million/year available for roadway maintenance - about half of what is needed

# The Research



© galactica216/reddit

# The Research

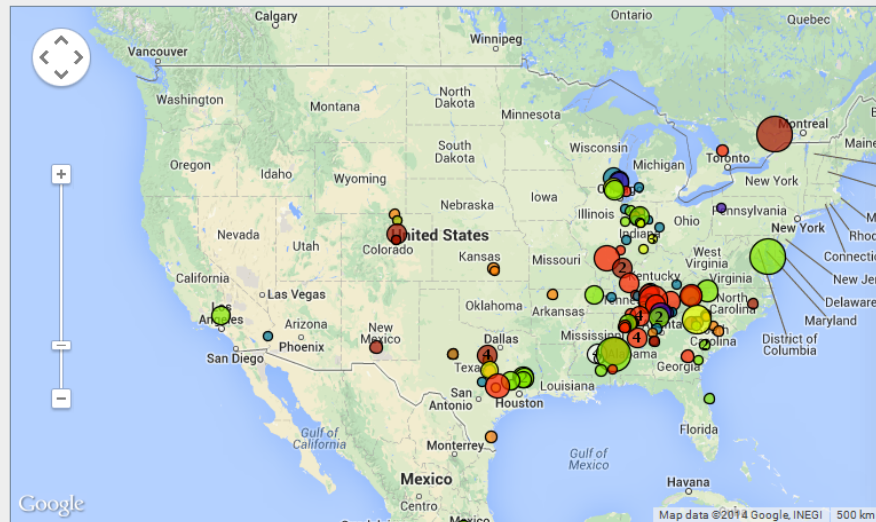
## The National RCC Explorer

[Instructions](#)

264 Items

MAP VIEW • TABLE VIEW • DETAILS VIEW

98 results out of 264 cannot be plotted.



Application

Airport Arterial Street Industrial/Trucking Facility Local Street Military  
Other (e.g., Logging Facility, Composting Area, Storage Yard) Port or Intermodal Facility Widening or Shoulder mixed

Search

Application

- 74 Industrial/Trucking Facility
- 52 Local Street
- 43 Port or Intermodal Facility
- 31 Military

State

Rolling Machine, High Compaction Density (1 Taper and 2 Pressure Bars or 2 Taper Bars)  
Pavement Joints: Yes  
Joint Spacing: 15 ft



RCC and PCC Installation  
Image 1 of 3

Pavement Joints: Yes  
Joint Spacing: 12.5-15 ft  
Joint Sealed: Yes

5 1990 - 1995

Project Size (SY)

- 165 0 - 50000
- 28 50000 - 100000
- 8 100000 - 150000
- 7 150000 - 200000

Nominal Maximum Size Aggregate

# The Research

RCC/AC Engineering Cost Estimates for Pleasant Grove			
<i>Option</i>	<i>Construct</i>	<i>50-yr. Maint.</i>	<i>Lifecycle Cost</i>
RCC over cement-treated subgrade	\$914,186	\$490,000	\$1,404,186
Asphalt over cement-treated subgrade	\$1,254,962	\$785,840	\$2,040,802

\$600K

# The Research

- **Open to light traffic tomorrow!**
- **48 hours for heavy-duty traffic!**
- **Build strong, durable roadways with environmental benefits**
- **20 to 25 years without Maintenance**



# The Research

- Project size/volume
- Pavement thickness and width
- Site geometry
- *Traffic control – opening to traffic*





# The Research



City of Roseville, California

# The Research



# The Research




# Outreach

## Past

- BIA
- Utilities
- Transportation Commission
- City Council – three times
- Hickory Public Meeting
- Social media


## Future

- City Council – award
- Project Tour
- City Council - NOC
- City Standard workshops
- City Council – Standard adoption


Roller Compacted Concrete (RCC)

**What is it?**


- Roller Compacted Concrete (RCC) is a relatively dry concrete mix that is installed with a paving machine and then rolled, just like asphalt
- It is sometimes called "white asphalt"
- This installation method keeps construction costs lower than conventional concrete and very competitive with asphalt
- RCC is generally 4" to 10" thick, installed in a single lift, and does not contain any reinforcing steel
- The City of Roseville requested a cost analysis from both a roadway contractor and an independent consultant. Both concurred that the RCC construction costs are about the same or lower than asphalt concrete (AC) costs for new roads.



*Arterial RCC*

RCC/AC Cost Comparison for Pleasant Grove (about 1/2 mile in length)			
Option	Construction Cost Estimate	50-yr. Maint. Cost Estimate	Lifecycle Cost Estimate
RCC over cement-treated subgrade	\$914,186	\$490,000	\$1,404,186
RCC over aggregate base	\$1,156,673	\$490,000	\$1,646,673
Asphalt concrete over cement subgrade	\$1,254,962	\$785,840	\$2,040,802
Asphalt concrete over aggregate base	\$1,509,170	\$785,840	\$2,295,010

RCC/AC Cost Comparison for Westpark Phase 4 Residential (about 1/2 mile in length)			
Option	Construction Cost Estimate	50-yr. Maint. Cost Estimate	Lifecycle Cost Estimate
Asphalt concrete over cement-treated subgrade	\$202,919	\$215,392	\$418,311
RCC over cement-treated subgrade	\$233,940	\$160,183	\$394,123
Asphalt concrete over aggregate base	\$244,607	\$215,392	\$459,999
RCC over aggregate base	\$255,897	\$160,183	\$416,080



**Roadway Maintenance Funding**

**The Challenge**

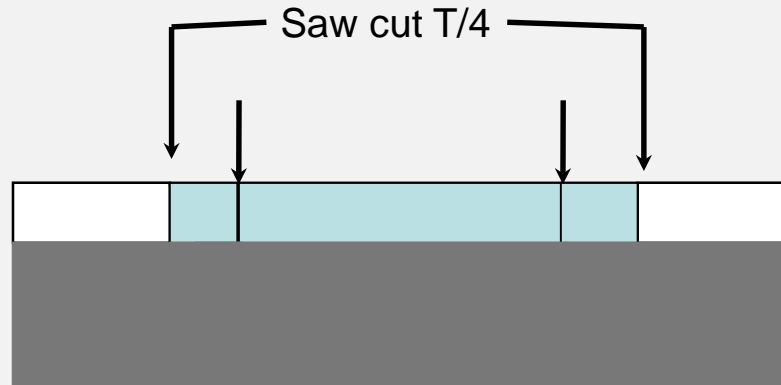
- The City maintains about 1,000 lane miles of asphalt roadway
- Proper asphalt preventative maintenance requires maintaining 100 lane miles per year at a cost of about \$8.5 million
- The City has on average \$4.4 million per year available for roadway maintenance—about half of what is needed
- Maintenance funds generally come from the Gas Tax paid at the pump

• Gas Tax is distributed to local government based on road lane miles and population

Public Works Department
roseville.ca.us/RCC

## How To Perform A Utility Repair

Un - Doweled



# Outreach



Select Language

Search...

Text Version | Mobile

- Residents
- Business
- Visiting
- Departments
- e-Services
- Apply
- Find
- Report
- Sign Up

Homepage > City Gov > Public Works > Roller Compacted Concrete

Email Print

- Administration
- Alternative Transportation
- Engineering
- FAQs (Public Works)
- Flashing Yellow Arrows
- Road Work, Closures & Detours
- Oak Ridge Drive Bridge Replacement Project
- Public Works Maps
- Real-Time Traveler Info
- Regional Projects
- Roadway Projects Status
- Roller Compacted Concrete
- Street Maintenance
- Traffic Volume Information
- Washington/Andora Widening Project
- Woodcreek Oaks Widening Project

## Roller Compacted Concrete (RCC)



Hickory Street with current asphalt surface



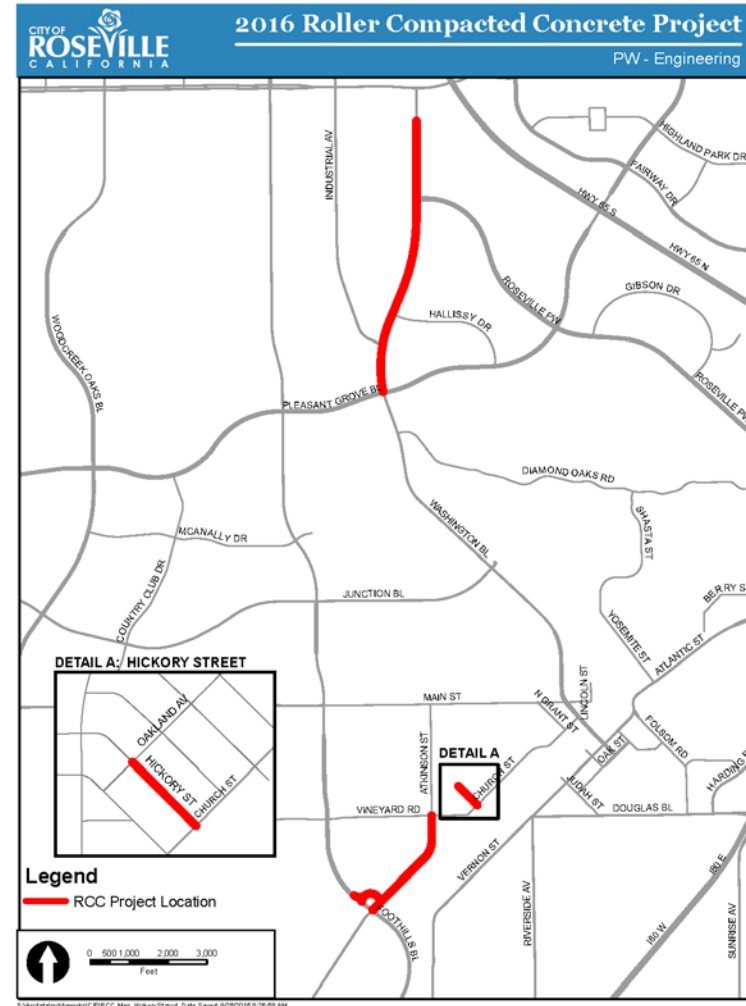
Simulated photo of Hickory Street with roller compacted concrete

### Pilot Project

The City of Roseville is beginning the design phase of a roadway reconstruction project testing a new paving material called Roller Compacted Concrete (RCC). Hickory Street, from Church to Oakland, has been identified as an ideal candidate to test this new pavement. The current failing asphalt roadway will be replaced with a new concrete surface. **Work is planned for spring/summer 2017.**

# Pilot Project

- Complete reconstruction of three sections of failed road – Washington, Atkinson/Denio, Hickory
- Three differing road types – arterial, collector, residential
- Three different finishes – natural, diamond grind, troweled



# Pilot Project

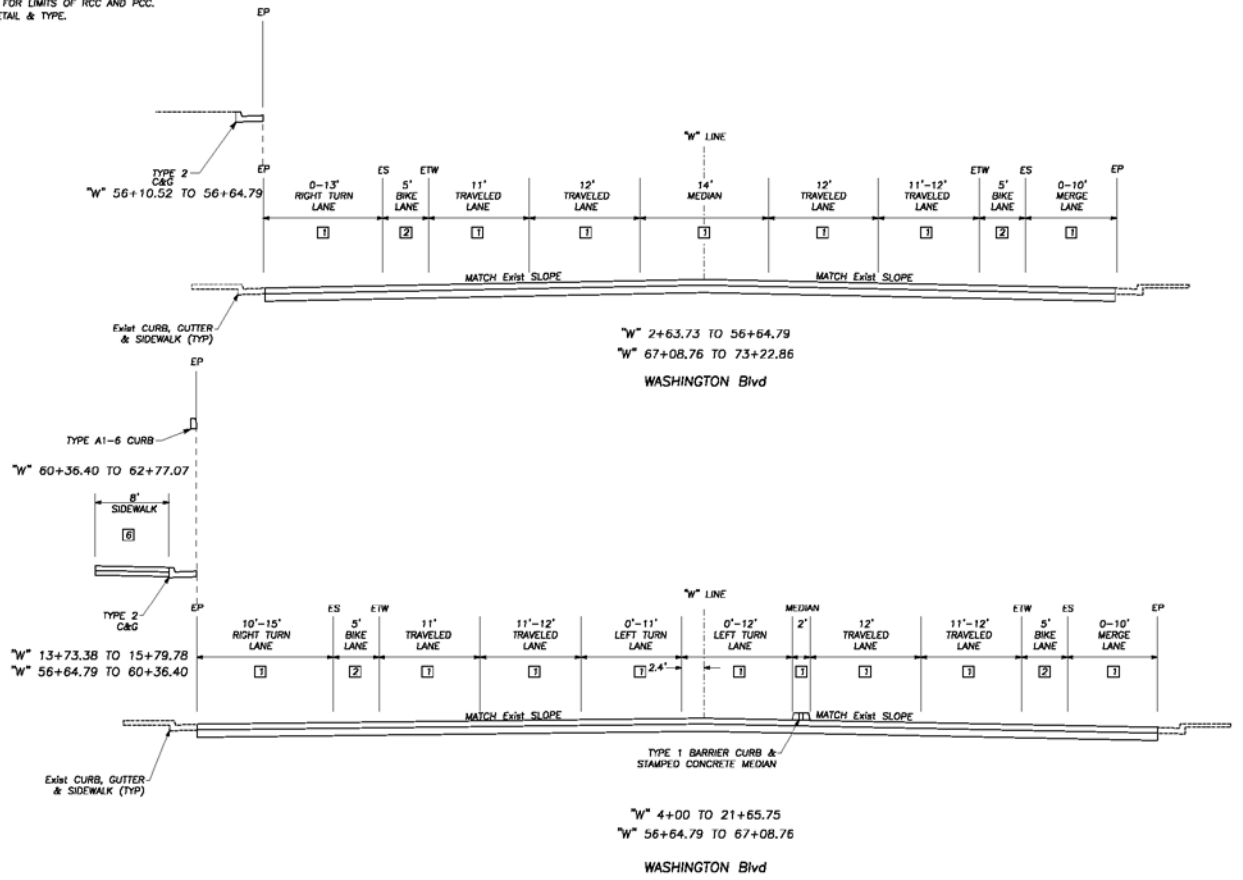


# Pilot Project

NOTES:  
 1. REFER TO LAYOUT SHEETS FOR CURB LOCATIONS.  
 2. REFER TO PAVEMENT AND JOINTING PLANS FOR LIMITS OF RCC AND PCC.  
 3. REFER TO RETAINING WALL SHEETS FOR DETAIL & TYPE.

**STRUCTURAL SECTIONS**

- 1 0.25" DIAMOND GRIND  
2" RCC OR PCC  
8" CTB
- 2 2" RCC OR PCC  
8" CTB
- 3 0.25" DIAMOND GRIND  
8.50" RCC OR PCC  
8" CTB
- 4 8.50" RCC OR PCC  
8" CTB
- 5 3" WOOD MULCH
- 6 4" PCC  
4" CL2 AB
- 7 4" HMA GRINDINGS
- 8 TROWELLED AND BROOMED FINISH  
5.5" RCC OR PCC  
8" CTB



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NO.	REVISIONS	BY	DATE	DESCRIPTION	DESIGN BY	CHECKED BY	DATE	PROJ. NO.
					CALLAN	L. J. RAY	06/09/2016	153116

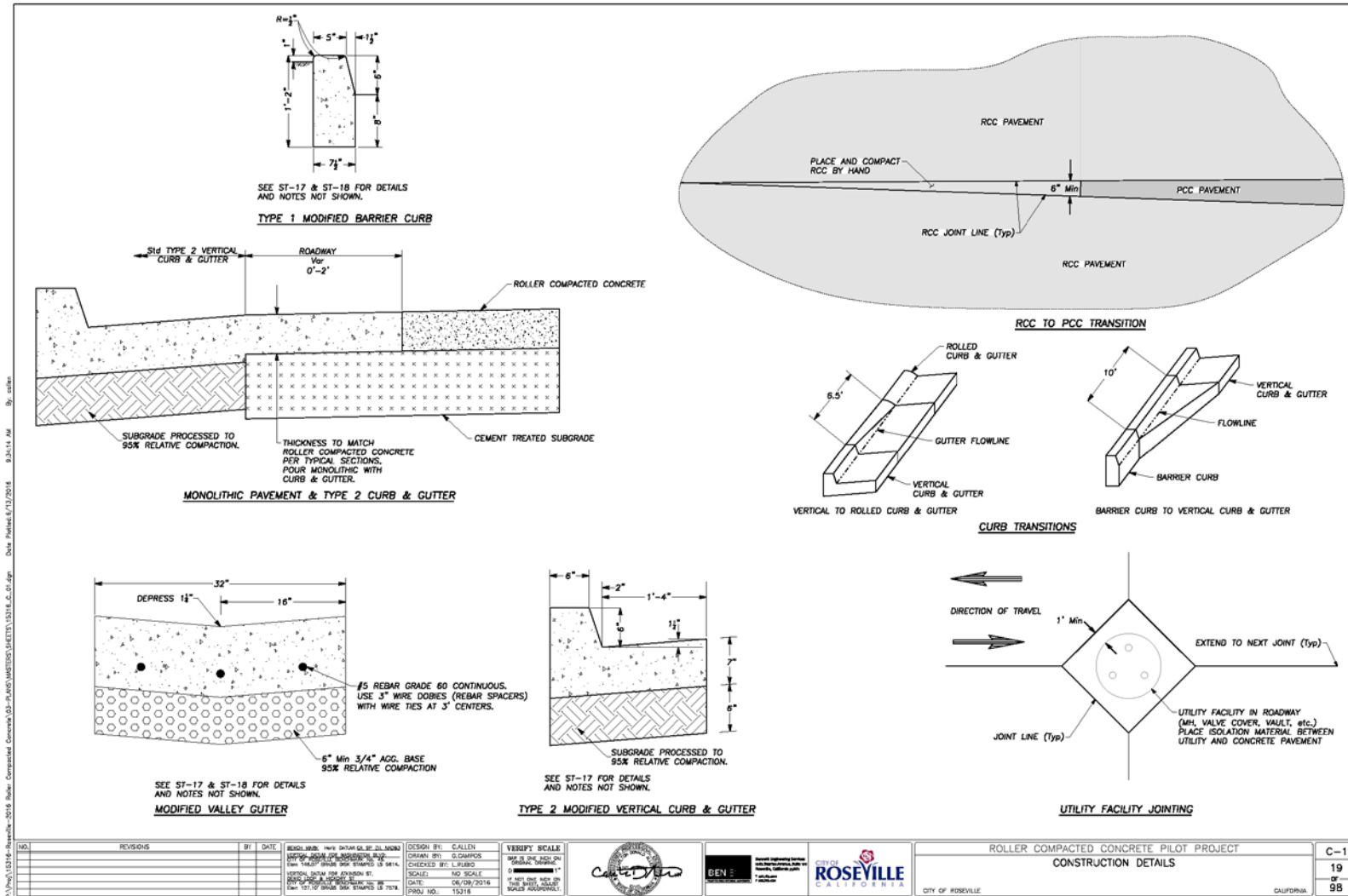
  

VERIFY SCALE SCALE: 1/4" = 1'-0" DATE: 06/09/2016 PROJ. NO.: 153116			
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ROLLER COMPACTED CONCRETE PILOT PROJECT TYPICAL CROSS SECTIONS WASHINGTON CITY OF ROSEVILLE, CALIFORNIA	X-1 3 OF 98
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# Pilot Project



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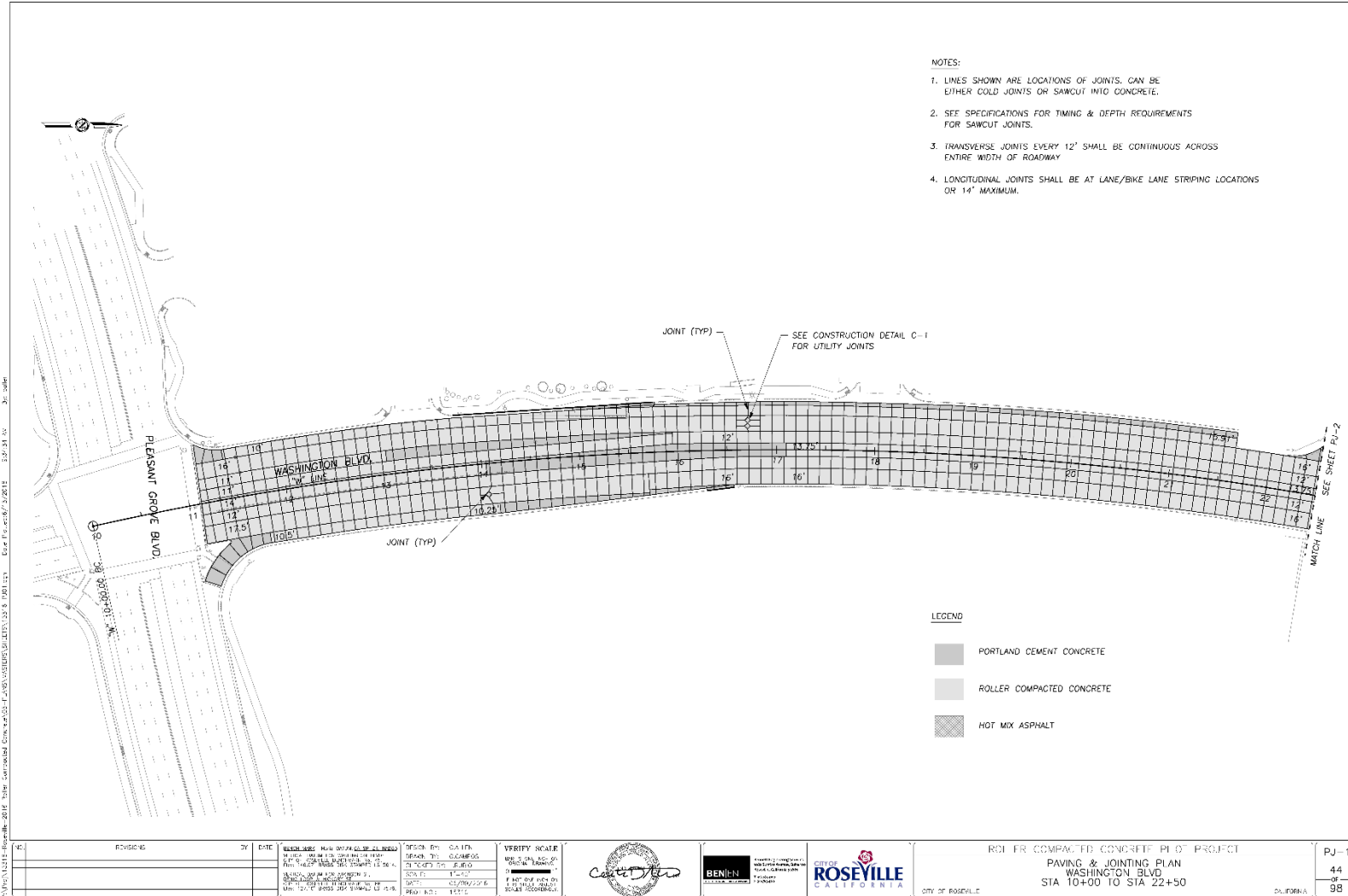
NO.	REVISIONS	BY	DATE

DESIGN NO.:	103116-03-19-16	DESIGN BY:	CALLAN
CHECKED BY:	L. RUBIO	SCALE:	AS SHOWN
DATE:	06/09/2016	PROJECT NO.:	103116

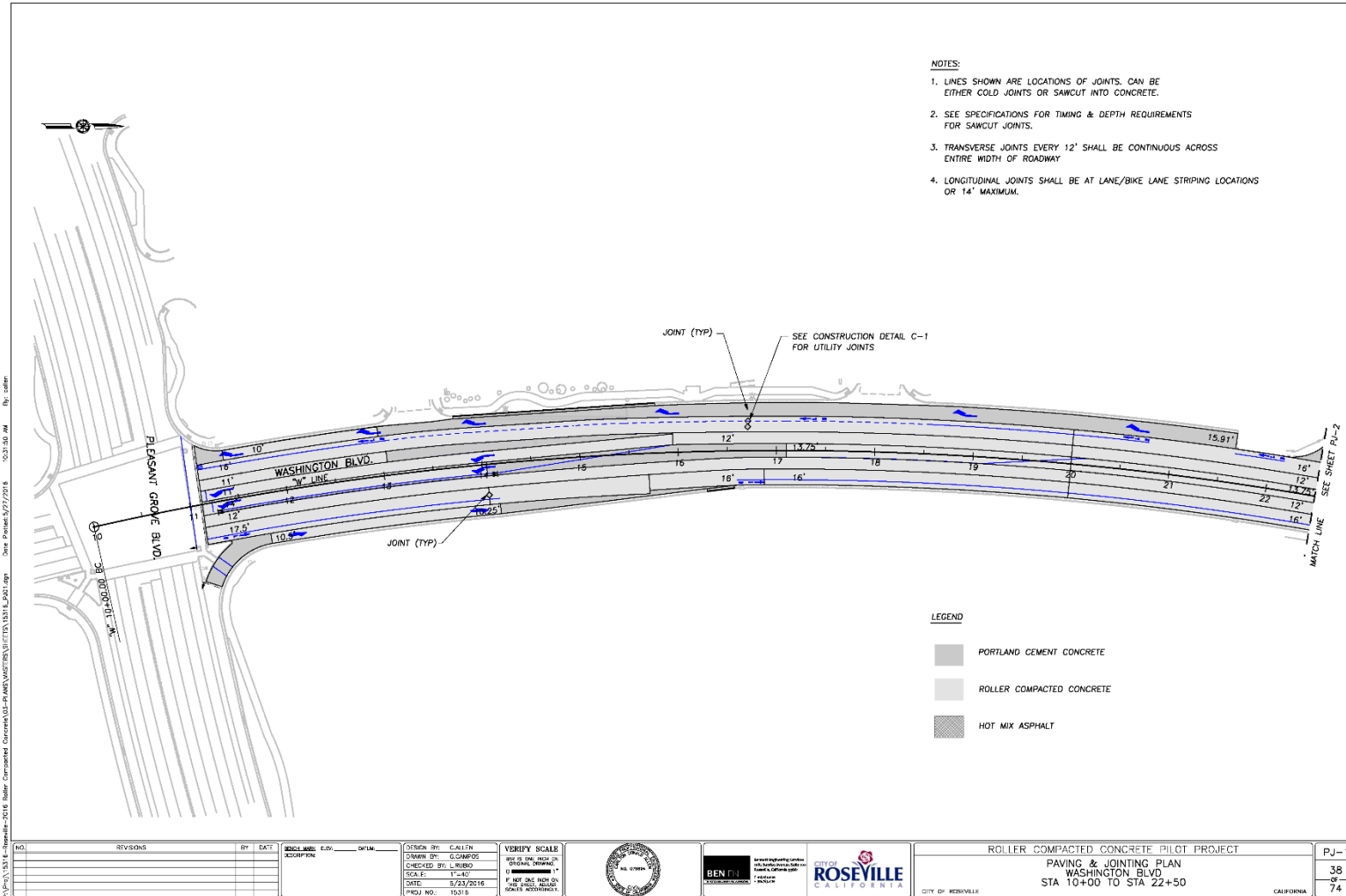


ROLLER COMPACTED CONCRETE PILOT PROJECT		C-1
CONSTRUCTION DETAILS		19
CITY OF ROSEVILLE		OF
CALIFORNIA		98

# Pilot Project



# Pilot Project

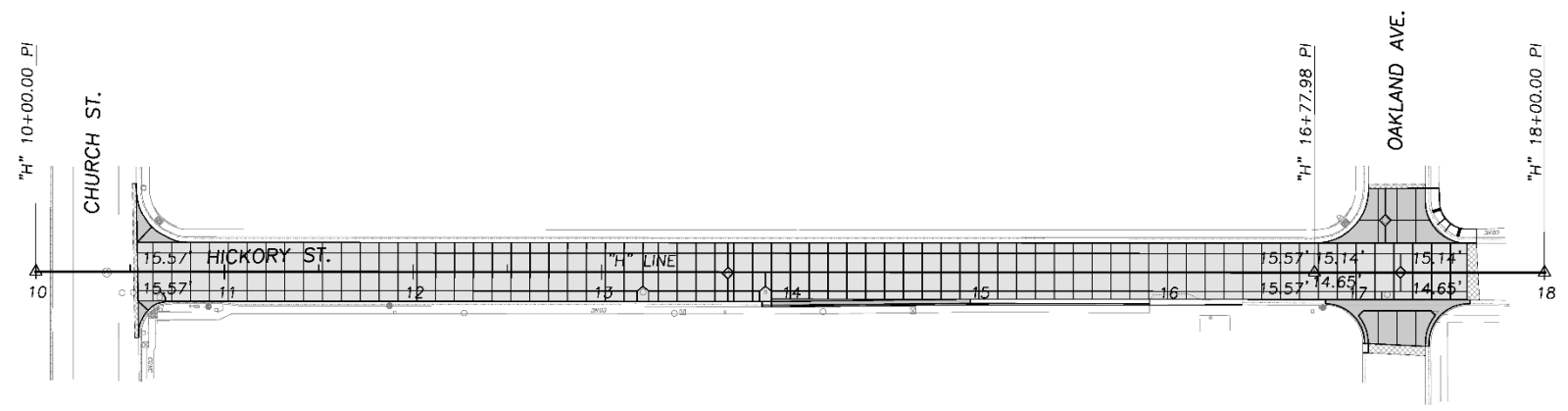


# Pilot Project

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RETE.  
EQUIREMENTS  
ONTINUOUS ACROSS

### LEGEND

- PORTLAND CEMENT CONCRETE
- ROLLER COMPACTED CONCRETE
- HOT MIX ASPHALT



# Pilot Project

## Roller Compacted Concrete Pilot Project

Public Works - Engineering



311 Vemon Street • Roseville, CA 95678 - 2849  
www.roseville.ca.us/engineering



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# Pilot Project

Item No.	Item	Unit	Estimated Quantity	Item Price	Subtotal
43	Surface Mounted Channelizer	EA	15	_____	_____
44	Object Marker (Type Q)	EA	10	_____	_____
45	Pedestrian Barricade	EA	5	_____	_____
46	Tape Pavement Striping and Markings and Pavement Markers	LS	1	_____	_____
53	Wood Mulch	CY	250	_____	_____
54	Signal Modification (Foothills Blvd and Denio Loop)	LS	1	_____	_____
55	Signal Modification (Washington Blvd and Pleasant Grove Blvd)	LS	1	_____	_____
56	Signal Modification (Washington Blvd and Hallissy Dr)	LS	1	_____	_____
57	Signal Modification (Washington Blvd and Roseville Pkwy)	LS	1	_____	_____
58	Signal Interconnect System	LS	1	_____	_____
59	Signal Modification (Stage Construction)	LS	1	_____	_____

**Total** \_\_\_\_\_

Contractor's Acknowledgement of Addendum # \_\_\_\_\_:

\_\_\_\_\_  
INITIAL          DATE

RCC Superintendent Name and Company (Resume to be included as part of the Bid Submittal): \_\_\_\_\_

High Density Paver Model Number and Owner Information: \_\_\_\_\_

Twin Shaft Pugmill Model Number and Owner Information: \_\_\_\_\_

# Pilot Project

## 5-1.06 SUPERINTENDENCE

In addition to Section 5-1.06 of the State Standard Specifications, the following apply:

As part of the bid package and **prior to Project award**, the prime contractor must have on their payroll, or be under contract with, **either a consultant or subcontractor** that will **provide** a **RCC Superintendent** for the project and provide documentation of such agreement. The RCC Superintendent shall be **present at the job** site during all items relating to **Roller Compacted Concrete**. Additionally, the contractor shall submit, as part of the bid package, the RCC Superintendent's resume. At a minimum, the RCC Superintendent's resume shall include the following:

- RCC Superintendent must have **experience with the equipment** required of the work including pugmills and high density pavers.
- RCC Superintendent must have a minimum of **3 years RCC Pavement experience**.
- RCC Superintendent must have **completed at least 3 RCC pavement projects** with a minimum of 2,000 CY each using the required equipment.
- **Three (3) RCC project references**, including photographs that are representative of the projects, must be included.
- Prime Contractor or RCC Superintendent must have completed at least 5 public roadway projects that included asphalt, PCC and/or RSC paving. Project references are required including photographs that are representative of the projects.

# Pilot Project

As part of their duties, the **RCC Superintendent** will be required to perform the following items:

- RCC Superintendent must submit and **conduct** a City approved **pre-construction RCC training program** agenda and trainer for both contractor and City staff involved with the RCC portion of the project.
- RCC Superintendent must oversee the prime contractor or subcontractor **perform at least one (1) 1,500 SY RCC paving test section** specific to this project prior to paving. This can be inclusive of the test sections required elsewhere in these specifications.

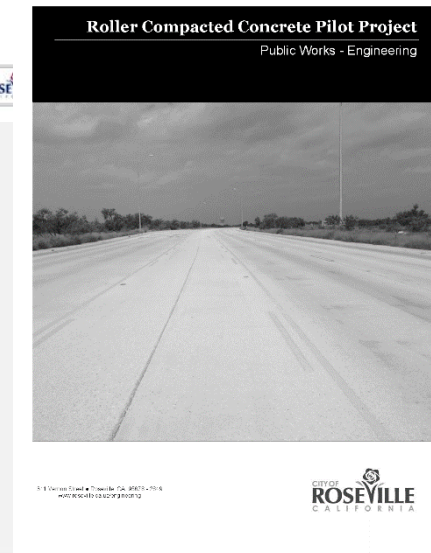
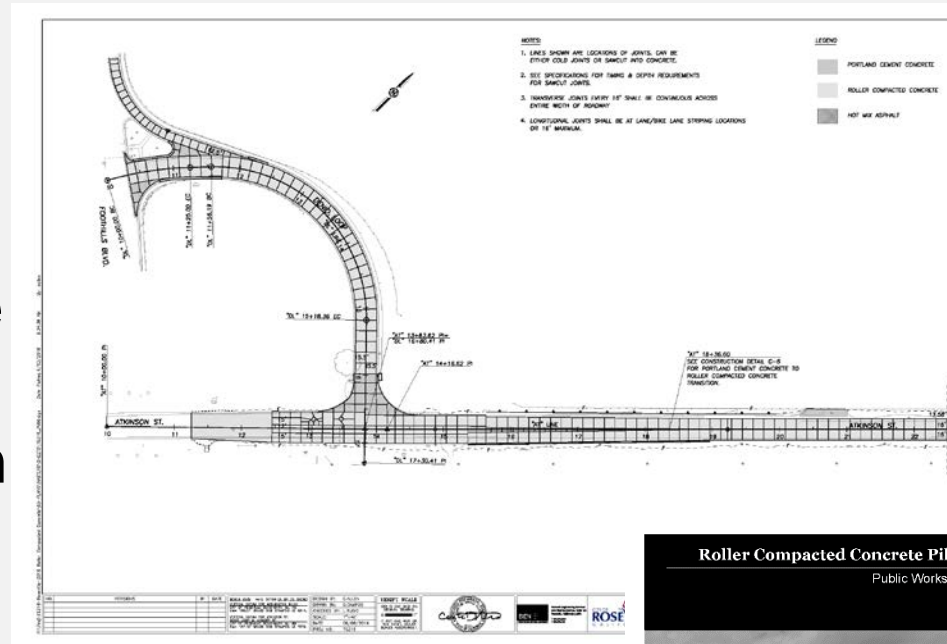
The Engineer has sole discretion to approve or reject the RCC Superintendent. If the proposed RCC superintendent is rejected, the contractor has three (3) business days to submit another RCC Superintendent for consideration by the Engineer.

# Pilot Project

<b>Washington RCC/AC Using 2016 Bid Results</b>		
<i>Location</i>	<i>Total Cost</i>	<i>Cost/SF</i>
8" HMA, 15" CTB, Cut and Export	\$3,558,202	\$7.02
RCC, PCC, CTB, Diamond Grind, Cut and Export	\$2,873,348	\$5.67

# Pilot Project

- Rebid this winter
- Advertise nationwide
- Begin construction in April
- Start at Atkinson/Denio, then Hickory, and finally Washington when school is out for the summer
- Completion Fall of 2017



# Pilot Project



## Resources:

- RCC Pavement Council
- Cemex
- National Concrete Pavement Technology Center
- Portland Cement Association
- American Concrete Pavement Association
- Lawrence Berkeley National Laboratories
- MIT Concrete Sustainability Hub
- Caltrans

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