Concrete Pavement Intersections

Presented By:

National **R**eady **M**ixed **C**oncrete **A**ssociation

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Your Instructor Today…

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  - NRMCA Local Paving, Northeast Region
  - 34 Years in Practice
  - Civil Site Design – Airfield Emphasis
  - lmchugh@nrmca.org

More information at paveahead.com/experts/

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About the Course

- **Learning Objectives:**
  - Understand the benefits of concrete intersections
  - Identify the special pavement design considerations for intersections
  - Learn the importance of properly jointing different intersection types including roundabouts
  - Recognize how decorative concrete can enhance safety and improve streetscapes at intersections

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National Ready Mixed Concrete Association

- National Trade Association – Established in 1930
- HQ in Alexandria, VA
- 400+ Member Companies
- NRMCA Represents ~75% of North American Ready Mixed Production
- Mission - Serve Industry and Partners Through:
  - Compliance and Operations
  - Engineering
  - Government Affairs
  - *Local Paving: Pave Ahead™ Initiative*
  - *Structures and Sustainability: Build With Strength™ Initiative*

Interested in becoming a member?

Visit: www.nrmca.org/membership/

NRMCA™

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The National Ready Mixed Concrete Association promotes the use of concrete products for pavement due to their safety, resilience, and long-term value.

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Local Paving: Market Areas

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Local Paving: Market Areas

Other Reasons

- My client wants asphalt pavements
- Asphalt pavements are cheaper
- Concrete pavements can’t handle freezing temps
- I can’t wait 28 days to open the pavement to traffic
- We just don’t do that up here

M-5 and Pontiac Trail - Michigan

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Washington County, MN

Source – Minnesota Concrete Association

Route 5 – Holyoke, MA

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Route 20 Westbound - Charlton, MA

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Concrete Intersections

Why The Need?

Common Problems at Intersections…

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Ideal for Concrete!

Concrete…

- is ***Durable***
- is ***Functional***
- is ***Sustainable***
- has a ***Long Life***
- has ***Low Maintenance***
- is ***Cost Effective***
- ***Saves $$$$*** *for other repairs, maintenance, and other projects*

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References for Course


CONCRETE PAVING Technology

ACPA

Concrete Intersections

A Guide for Design and Construction

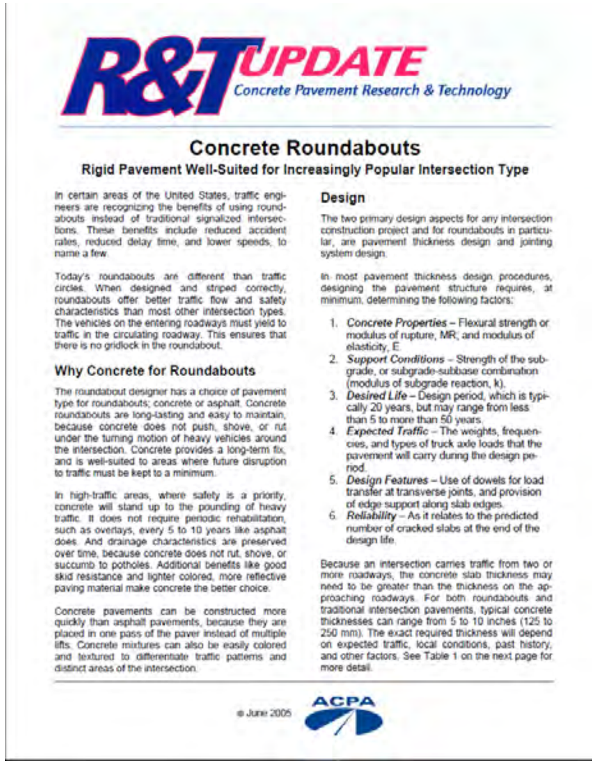
Introduction


CONCRETE PAVING Technology

ACPA

Intersection Joint Layout

Joint Layout Terminology


R&T UPDATE Concrete Pavement Research & Technology

Concrete Roundabouts

Rigid Pavement Well-Suited for Increasingly Popular Intersection Type

Design

Why Concrete for Roundabouts

ACPA

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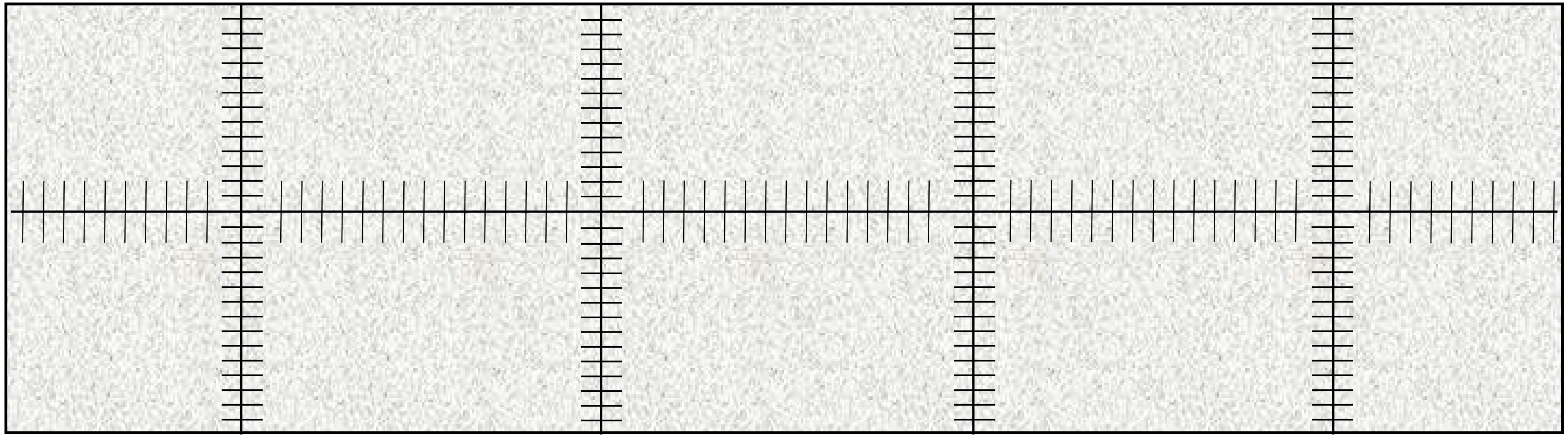
Intersections and Roundabouts

What Kind of Concrete Pavement is Recommended? Jointed – Unreinforced Pavement

Plan



Profile

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Define the Traffic Streams Through the Intersection

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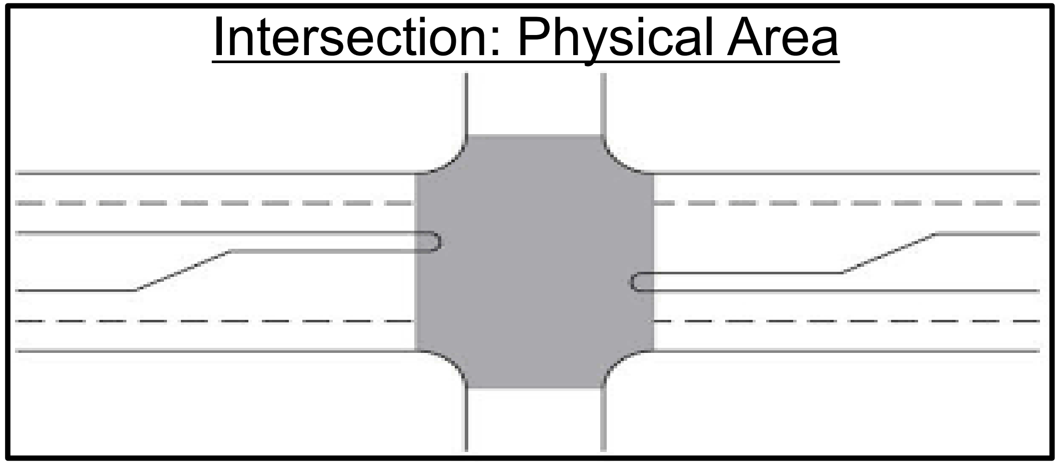
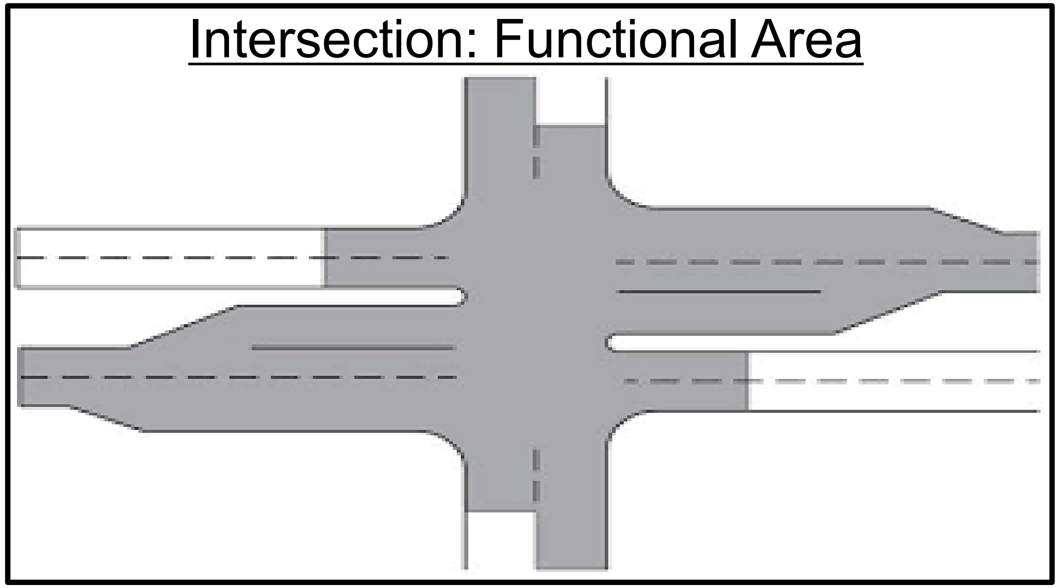
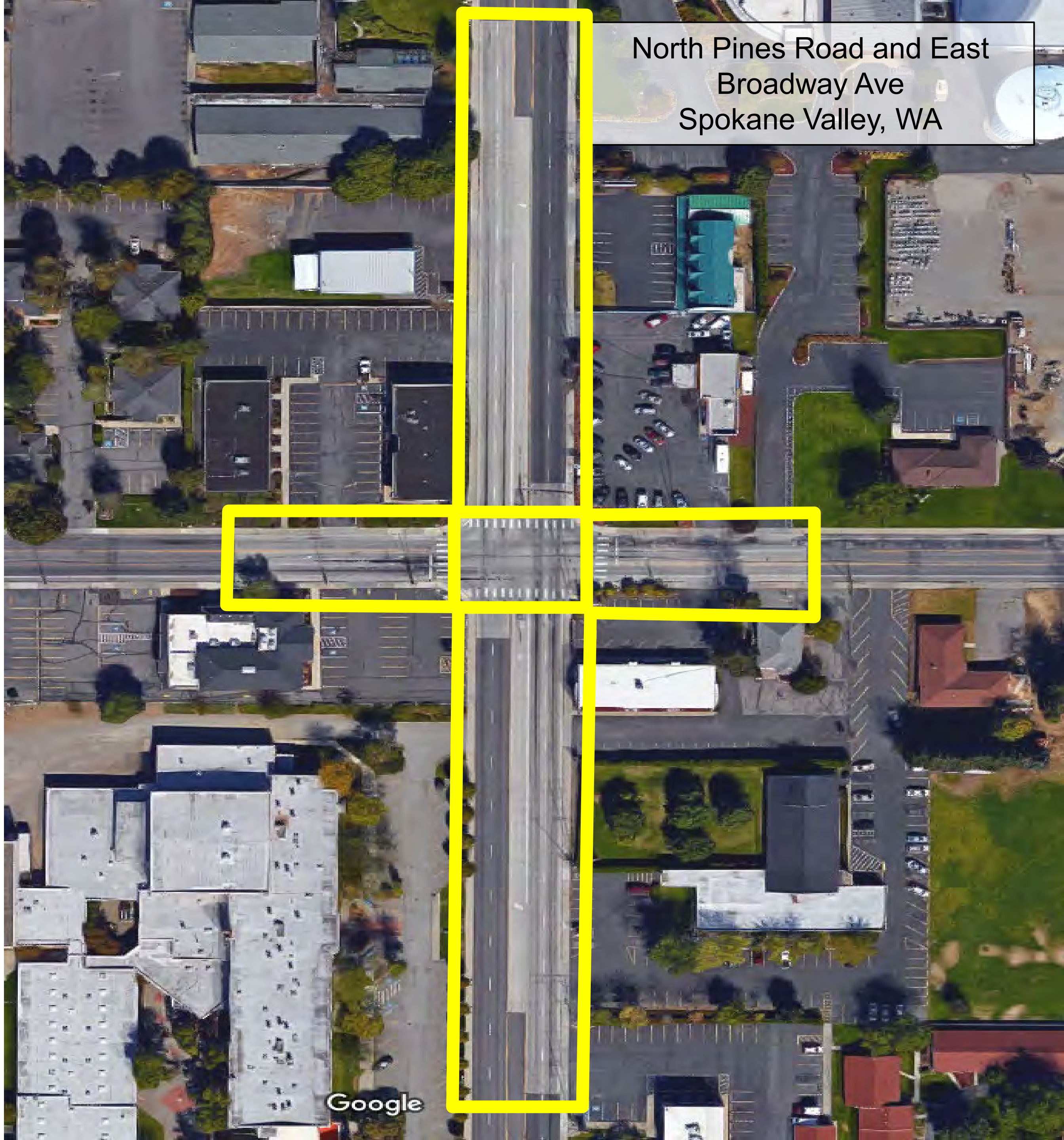
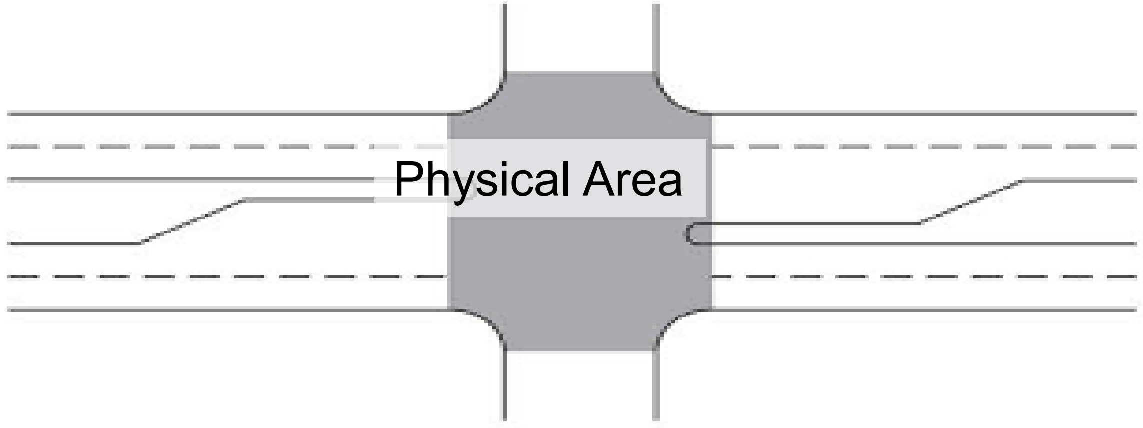
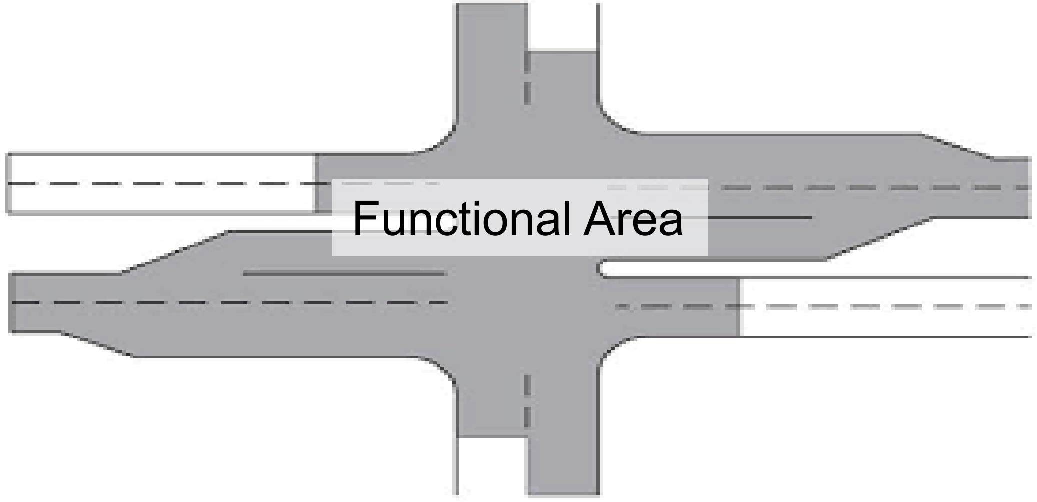

Intersection: Physical Area


Intersection: Functional Area


North Pines Road and East
Broadway Ave
Spokane Valley, WA
Google

Concrete Intersections: Thickness





Roadway 1	Roadway 2	Physical Area Thickness
Low AADT (T1)	Medium AADT (T2)	T2
Low ADTT (T1)	High AADT (T3)	T3
High AADT (T3)	High AADT (T3)	T3 + 0.5 to 1.0 in.

Note: T3 > T2 > T1

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Source: ACPA



Concrete Intersections

When is the Best Time?


Utilizing Concrete For Intersections

New Construction

Reconstruction

Overlay / Inlay

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Life Cycle Costs Analysis for Intersections Washington State (with user costs)

40 Year Annualized Cost					
SR	**Intersection**	**Concrete**	**AC with 4 yr Inlay**	**AC with 6 year Inlay**	**AC with 8 year Inlay**
27	Sprague Ave.	$33,000	$46,800	$39,500	$35,800
90	Thierman St.	$54,300	$66,400	$57,600	$53,100
2	Francis Ave.	$73,500	$100,900	$87,000	$79,900
291	Maple & Ash St.	$33,900	$50,800	$42,100	$37,600
27	Broadway Ave.	$36,100	$51,000	$42,600	$38,300
395	19th Ave.	$29,700	$45,800	$37,800	$33,700
2	Third Ave.	$15,200	$18,700	$16,500	$15,400

www.wsdot.wa.gov

Concrete Intersections - Considerations

- For existing pavement: Complete reconstruction or overlay/inlay?
- Concrete intersection construction limits
- Thickness Design
- Subgrade and subbase requirements
- Jointing details
- Pavement profiles
- Concrete materials (early opening strength for fast-track paving?)
- Concrete to asphalt transitions
- Coordination with local businesses
- Incorporating decorative elements

Courtney Park and Kennedy Road
Mississauga, Ontario

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Concrete Intersections - Considerations

- For existing pavement: Complete reconstruction or overlay/inlay?
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Concrete Intersections

Pre-Design Information Gathering


What Do We Know?*

- Pavement Condition Evaluation
- Pavement Materials Analysis (Destructive/Non-Destructive Testing)
- Existing Pavement Structural Layers (cores, borings, etc.)
- Subgrade Soils (borings, DCP, etc.)
- Expected Future Traffic and/or Use (Service Life)
- Roughness (Smoothness)
- Drainage Conditions
- Grade & Elevation Restrictions

*Typically requires hiring knowledgeable consulting engineer.

Pavement Condition Evaluation

- Identify Types of Distress
  - Fatigue (Alligator) Cracking
  - Rutting
  - Transverse or Longitudinal Cracking
  - Etc.

- Identify Severity of Distress
  - Low, Medium, High

- Identify Quantity of Each Type/Severity
  - ft^2, in., ft, etc.

Destructive Testing Options

Coring

Trenching

Dynamic Cone Penetrometer (DCP)

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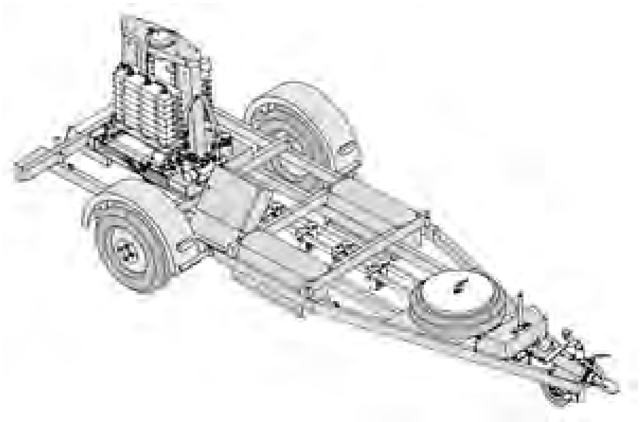
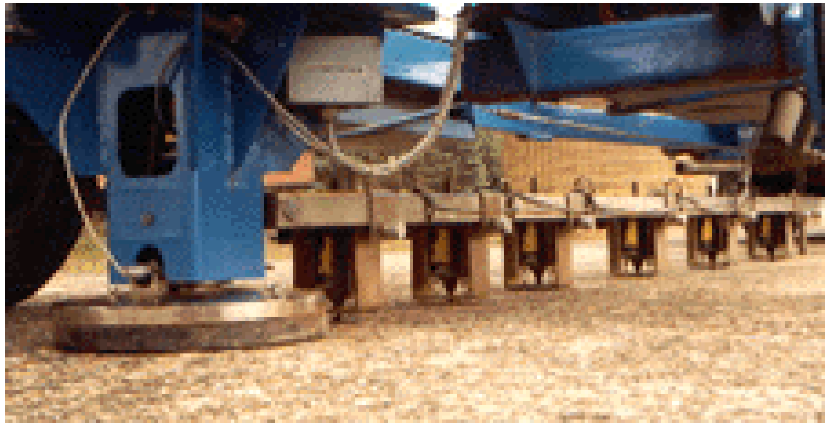
Coring

- Layer confirmation
- Layer thicknesses
  - Variability
  - Minimum requirements for thin overlays
- Subsurface conditions
  - Stripping
  - Delamination
- Samples for laboratory testing
  - Material properties

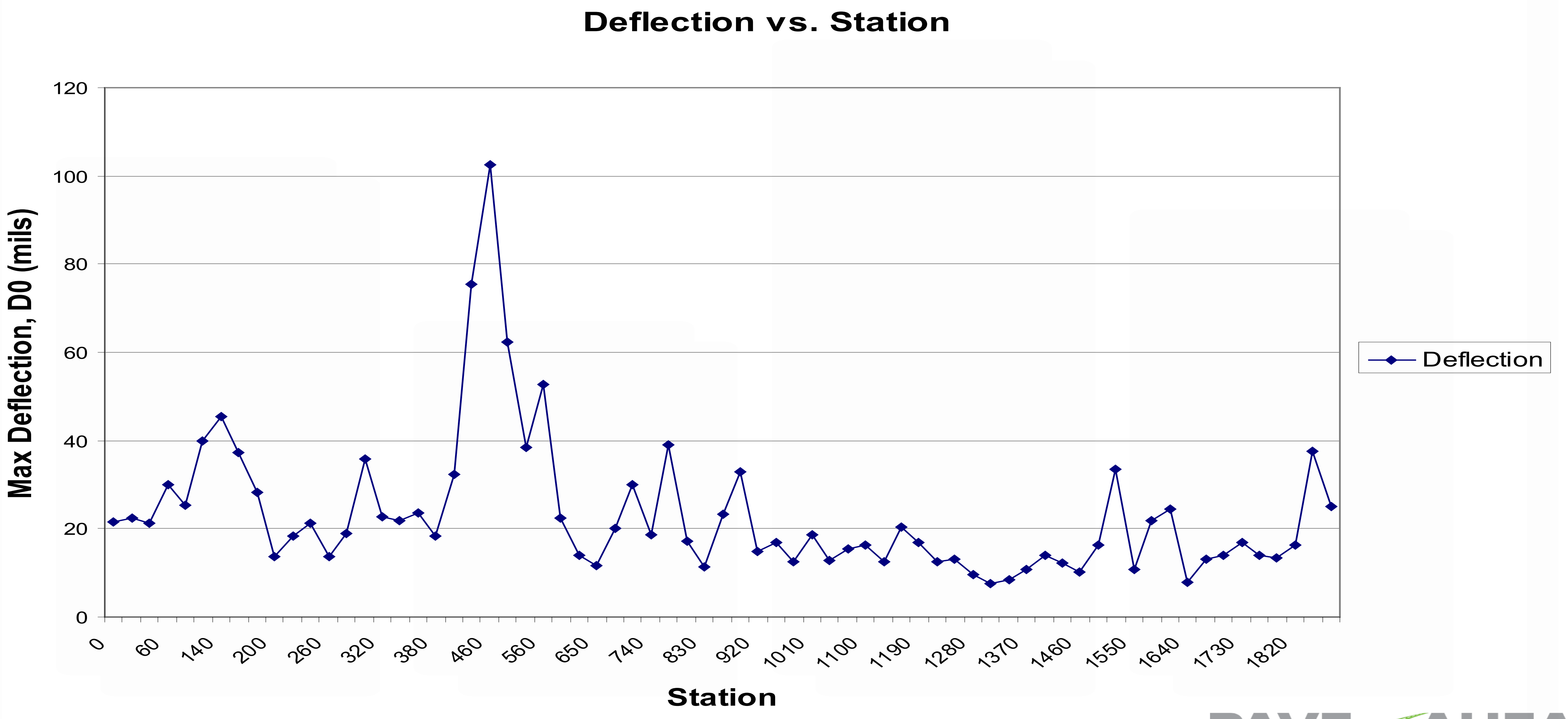
Pavement Structural Capacity

- Falling Weight Deflectometer (FWD)





Pavement Structural Capacity



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Analysis of Evaluation Data

- Combine Information From:
  - Visual Distress Survey
  - FWD
  - Cores, Soils, etc.
  - Drainage Survey and Grade Restrictions
- Determine Structural Adequacy of Existing Pavement
- *Make Decision:* Reconstruct, or Concrete Overlay?

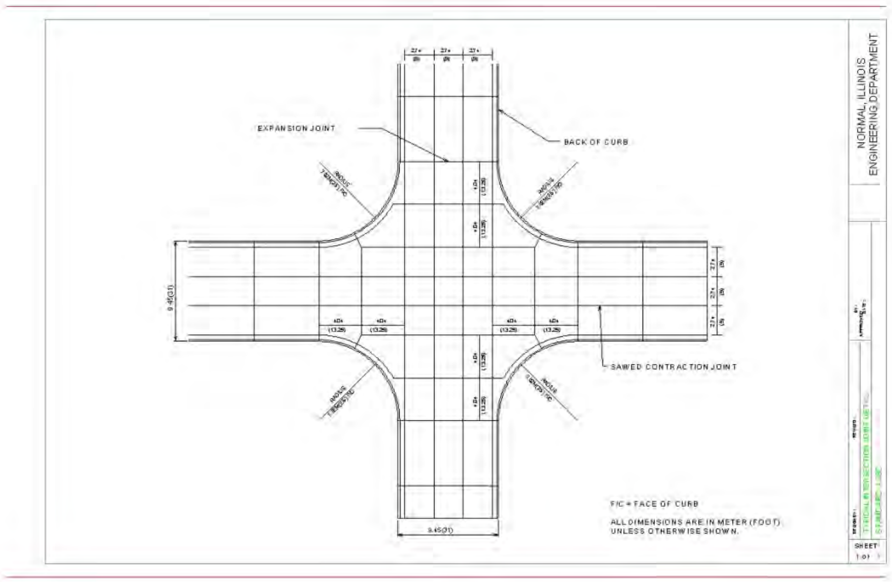


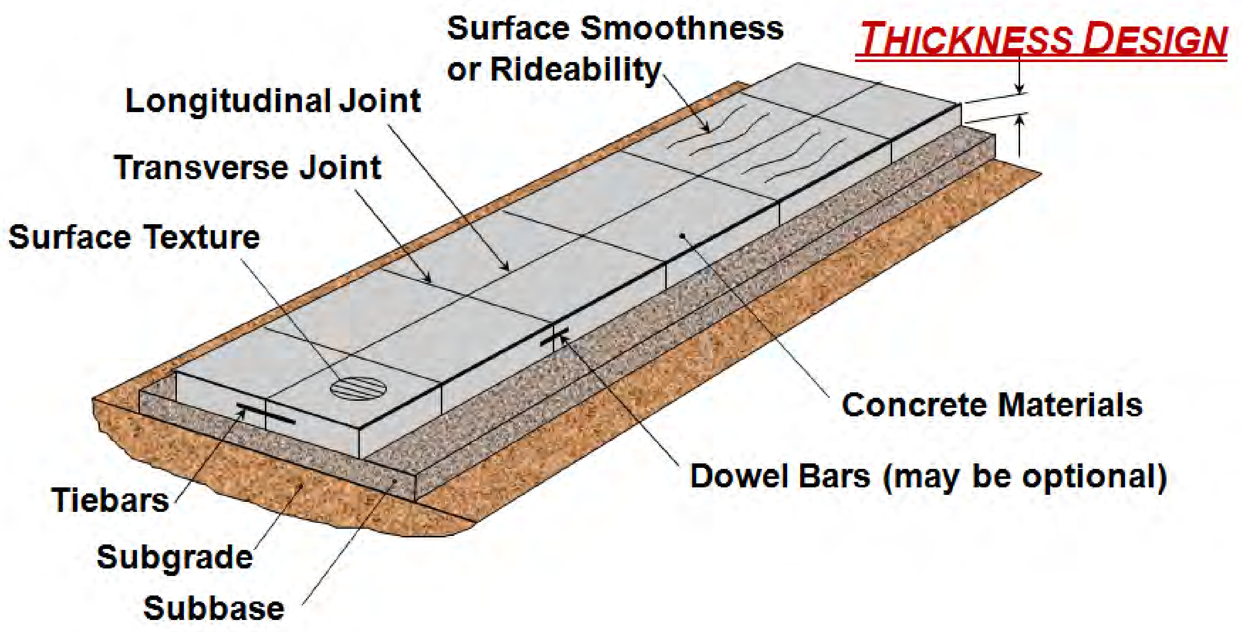
Concrete Intersections

Pavement Thickness Design Methods


Primary Information Needed For Thickness Design

- Traffic Information
- Underlying Support Condition
- Concrete Strength





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Subgrade Soil Characterization

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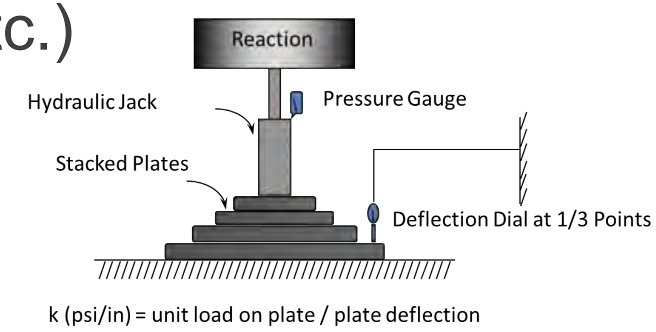
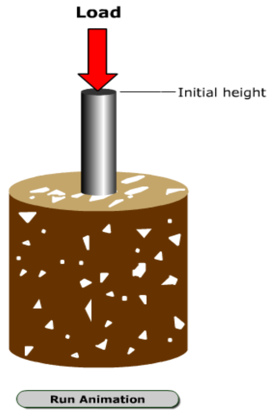
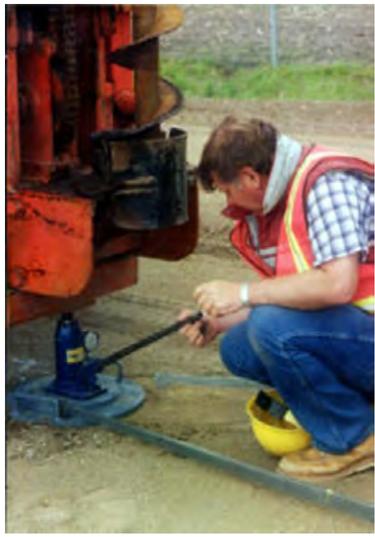
Suitability of Subgrade Soils

- Classification (Gradation, Atterberg Limits, etc.)
- Depth to Bedrock
- Depth to Water Table
- Potential for Compaction
- Presence of Weak or Soft Layers or Organics
- Susceptibility to Frost Action or Excessive Swell
- Soil Strength Characteristics
  - Modulus of Subgrade Reaction (k value)
  - Easily related to CBR
  - CBR usually cheaper and easier to run
  - Soil strength more important flexible pavements







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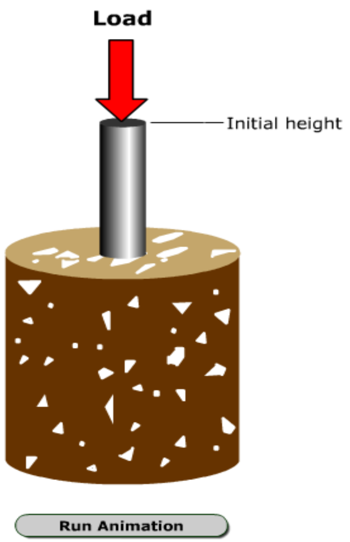
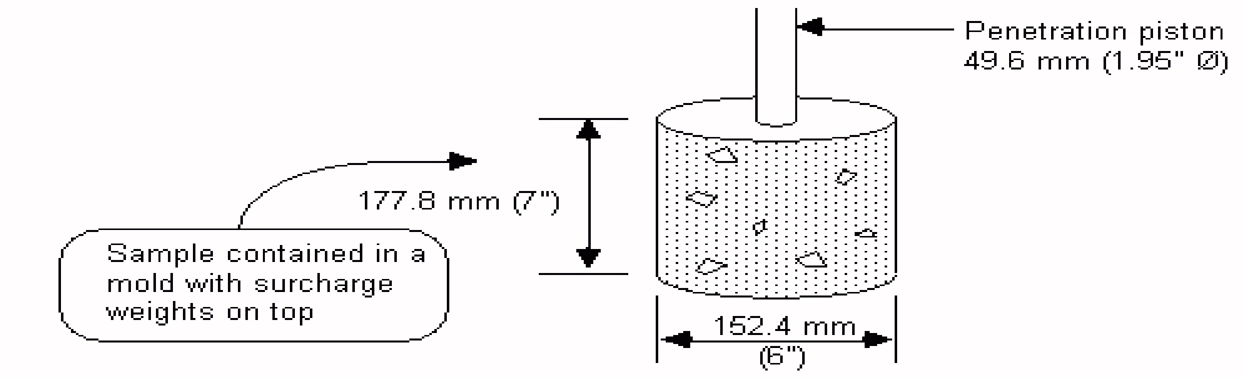
California Bearing Ratio (CBR)

- Load a piston at a constant rate (0.05 in/min)
- Record Load every 0.1 in penetration
- Total penetration not to exceed 0.5 in.
- Draw Load-Penetration Curve.
- Determine CBR from Curve.





Concrete Strength

- Design = Modulus of Rupture (MOR)
  - Sometimes referred to as Flexural Strength
- Construction = Compressive Strength ($f'c$)
- MOR = 8 to 10 * $\sqrt{f'c}$
  - MOR ~ $f'c$
  - 500 psi ~ 3,500 psi
  - 550 psi ~ 4,000 psi
  - 600 psi ~ 4,500 psi
  - 650 psi ~ 5,000 psi

MOR

$f'c$

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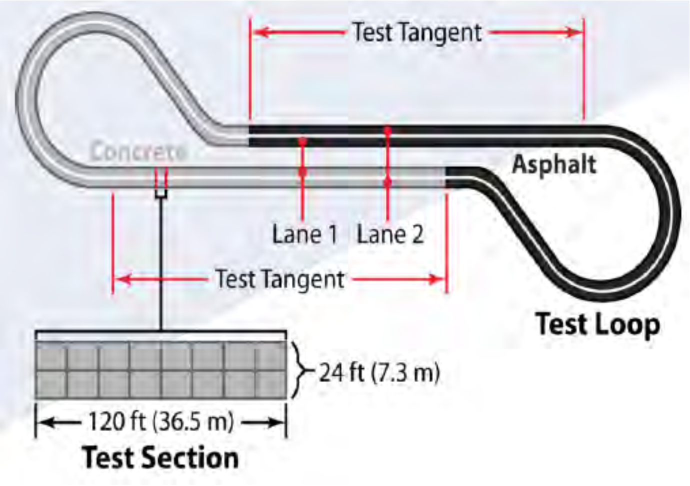
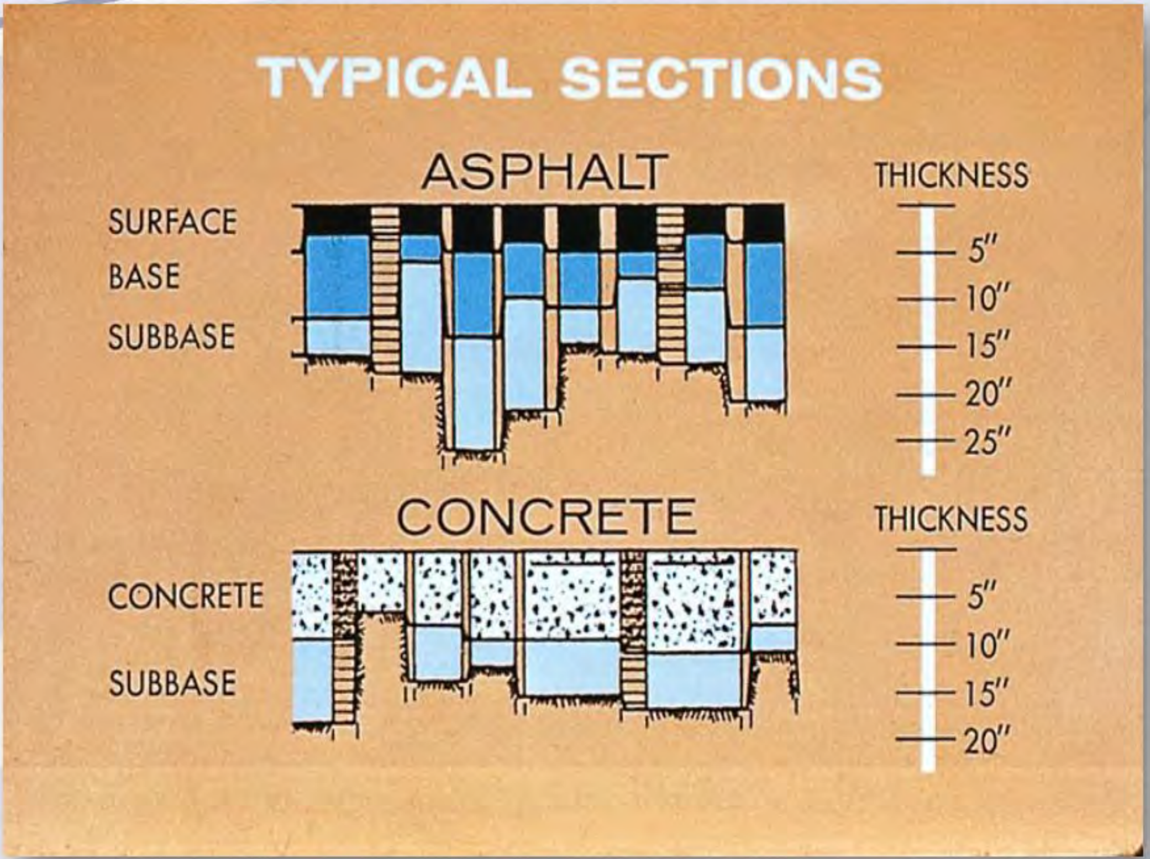
Source of Much of What We Know About Pavement Design

- AASHO Road Test (1958-1960)
- Ottawa, Illinois - 1.1 Mil Reps
- Wholly empirical
- 368 concrete and 468 asphalt sections
- Focus was ***highway pavement***



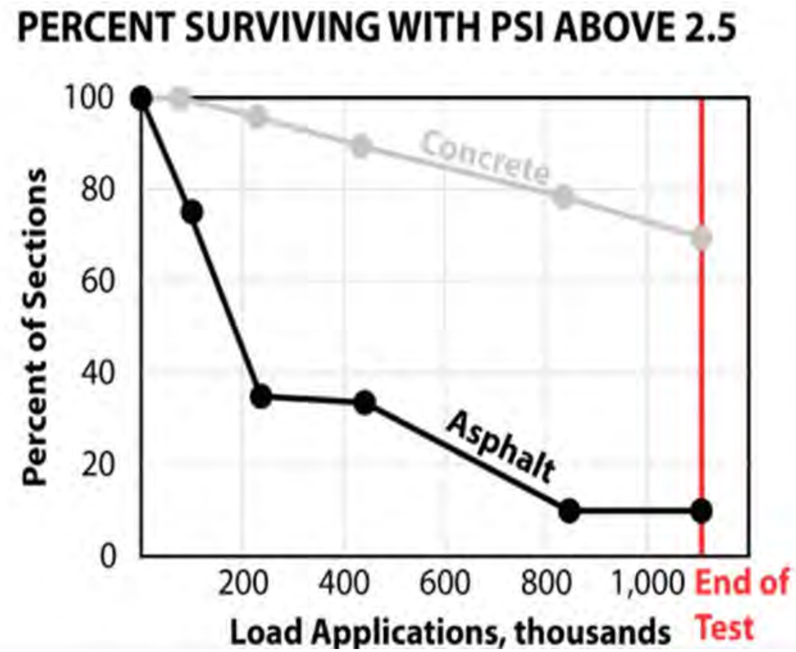
Test Sections or ***Guessed Sections***

Necessary Thickness was Guessed!



Subgrade = Clay Soil

Source: Ferrebee ACPA



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1986-93 JPCP AASHTO 93 Equation

$$Log(ESAL) = Z_R * s_o + 7.35 * Log(D+1) - 0.06 + \left[\frac{Log\left[\frac{\Delta PSI}{4.5-1.5}\right]}{1+\frac{1.624*10^7}{(D+1)^{8.46}}}\right]$$

$$+ (4.22 - 0.32 * p_t) * Log\left[\frac{S'_c * C_d * (D^{0.75} - 1.132)}{215.63 * J * \left[D^{0.75} - \frac{18.42}{(E_c / k)^{0.25}}\right]}\right]$$

Standard Normal Deviate (Z_R)

Overall Standard Deviation (s_o)

Thickness (D)

Change in Serviceability (ΔPSI)

Traffic ($ESAL$)

Terminal Serviceability (p_t)

Modulus of Rupture (S'_c)

Drainage Coefficient (C_d)

Load Transfer (J)

Modulus of Elasticity (E_c)

Modulus of Subgrade Reaction (k)

WHAT DO DESIGNERS FOCUS ON?

Source: ACPA

New Construction or Reconstruction: Pavement Thickness Design Software (JPCP)

PavementDesigner.org

<u>Inputs:</u>

- Design Life
- Traffic
- Soil Strength
- Concrete Strength
- Base Properties (if used)
- Reliability (Factor of Safety)

<u>Outputs:</u>

- Concrete Thickness
- Joint Spacing
- Doweling

Typical Design Inputs: Concrete Overlay

- Current and Future Traffic Loading
- Soil Strength
- Concrete Strength
- Location (For Temperature Thermal Gradient Calculation)
- Reliability
- Fibers (Residual Strength Ratio)
- Underlying (Existing) Pavement Thickness/Strength
- Slab Dimensions
- Bond Condition
- Output: Required Overlay Thickness

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Concrete Intersections

Construction Details and Jointing


Concrete Materials & Mix Design

- Conventional Concrete Mixes Used for <u>Reconstruction</u> or <u>Overlay</u>
  - 4,000 psi Compressive (600 - 650 psi Flexural)
    - Type I/II Cement (Type III Cement for High Early Strength When Quick Opening is Required)
    - High Cement Content/Low Water Content Desired (max. w/cm~0.45)
    - Add SCMs to improve durability
  - Maximum Top Size ¾” for Thin Overlays
    - Coefficient of Thermal Expansion Must Be Considered
  - Admixtures for air, etc.
    - Reduce Water
    - Accelerate Set/Strength
  - Fibers May be Used (Micro or Macro Synthetic, Steel, or Blend)
    - Improve Toughness
    - Improve Post-Cracking Behavior
    - Reduce Plastic Shrinkage Cracking

Fiber-Reinforced Concrete

- Fiber reinforcement should be considered in any of the following situations:
  – The project has specific vertical restrictions
  – The asphalt lift is very thin (and thus may not readily bond with the concrete)
  – The base thickness and/or condition is inadequate
  – The design thickness makes conventional reinforcement for load transfer difficult to use.

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Considerations: New Construction/ Reconstruction of Intersection

- Removal of existing pavement (reconstruction)
- Preparing the grade
- Setting forms or slip form paver
- Placing in-pavement structures
- Other details prior to placing concrete
- Placing, finishing, and texturing the concrete
- Curing the concrete
- Saw cutting the pavement
- Sealing/Filling joints
- Opening to traffic

Considerations: Intersection Overlay/Inlay

- Place concrete when surface temperature is **<u><120° F</u>**.
- Conventional fixed-form or slip form placement used.
- Shotblast or mill (if needed) and clean surface thoroughly.
- Grout or epoxy bonding agents are not required.
- Texture pavement for friction.
- Curing material must be placed as soon as possible (<30 minutes). Full coverage is essential.
- Begin sawing as soon as possible (use of early entry saw is recommended).

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Pre-Overlay Preparation (Asphalt)

- Spot repairs as needed.
- Mill for grade correction and drainage transition.
- Sweep or wash clean to maximize bond.
- Address rutting if present.
- If needed, fill expansion cracks and any other deep cracks in asphalt to prevent keying of concrete into cracks.

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Overlay: Typical Concrete Overlay Construction Sequence

1-Mill

2-Clean

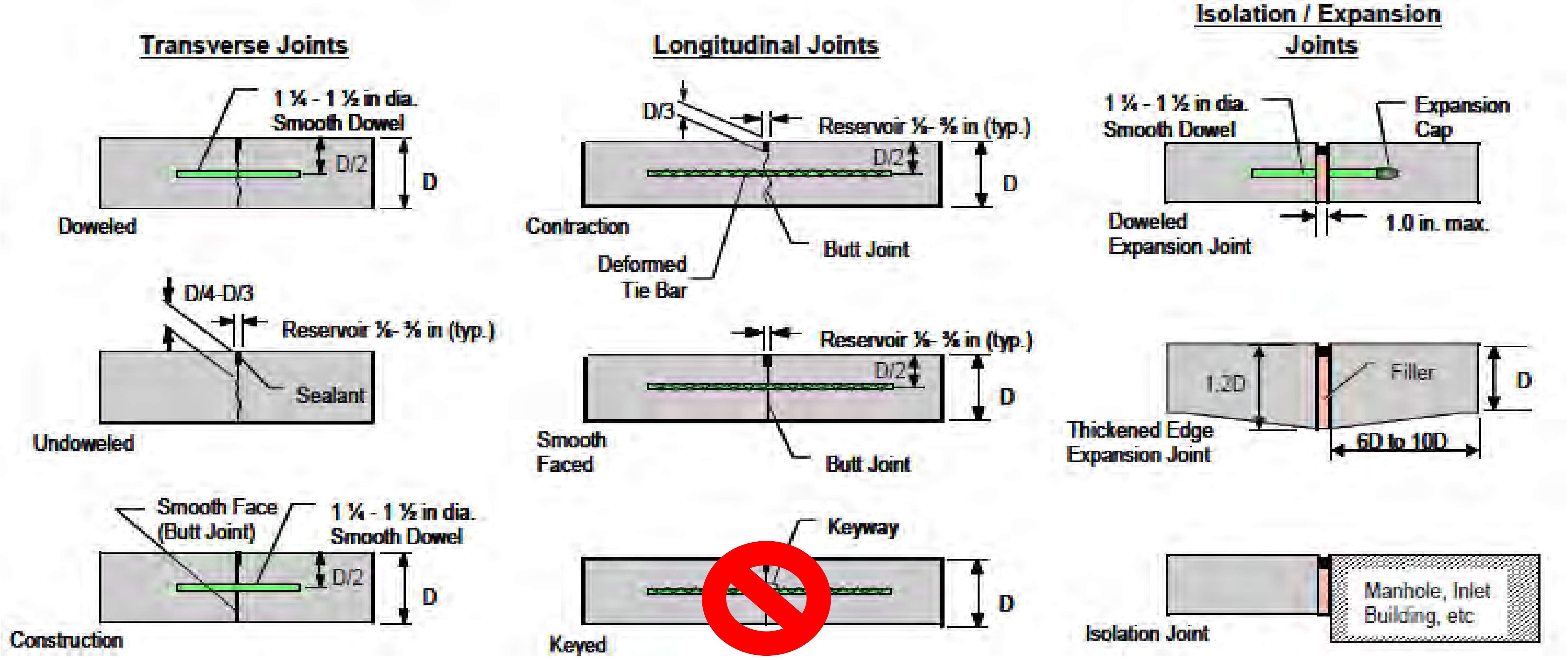
3-Place

4-Texture

5-Cure

6-Joint

Jointing: Joint Types



≥ 8 in.

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 Source: ACPA

Jointing: Common Intersections

- To Do:
  - Crack due to severe acute angle
  - Match existing joints or cracks.
  - Place joints to meet in-pavement structures.
  - Be mindful of the maximum joint spacing.
  - Place isolation joints where needed.
  - Allow necessary adjustments to joint locations in the field.
  - Be practical.

- To Avoid:
  - Slabs < 2 ft (0.6 m) wide.
  - Slabs > 15 ft (4.5 m) wide, unless local experience dictates otherwise.
  - Angles < 60° (~90° is best); do this by dog-legging joints through curve radius points.
  - Creating interior corners.
  - Odd shapes (keep slabs near-square or pie-shaped).

Source: ACPA

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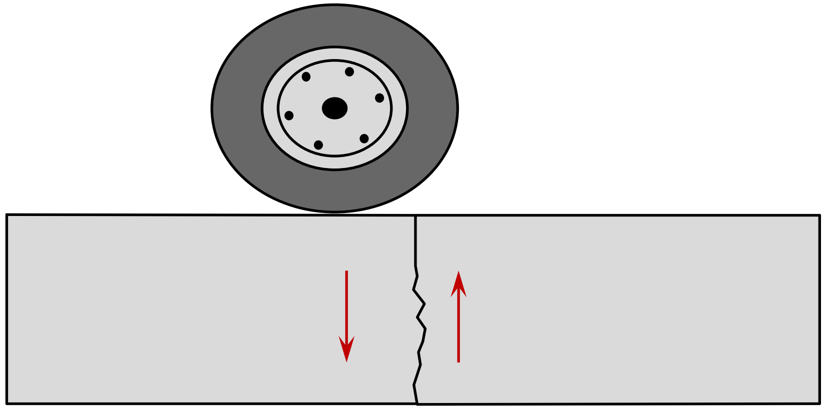
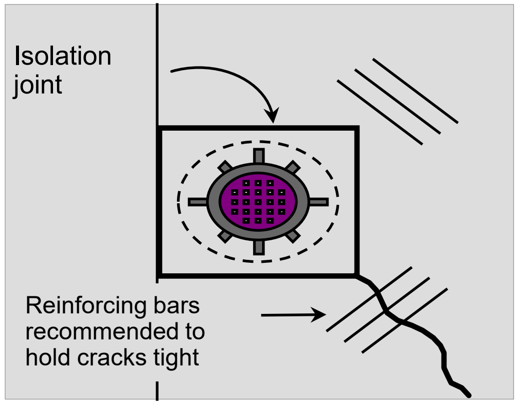
Forming Contraction Joints by Saw Cutting



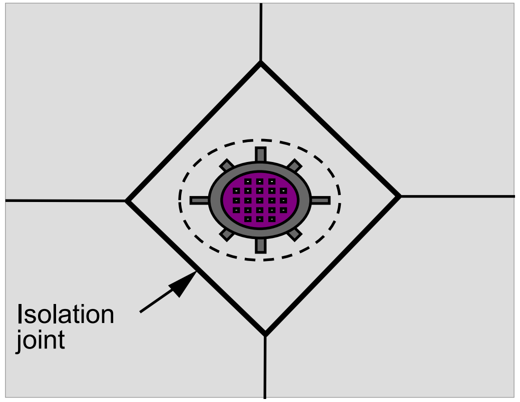
Conventional Sawcut
¼ to ⅓ of thickness

Early Entry Sawcut
~1 inch

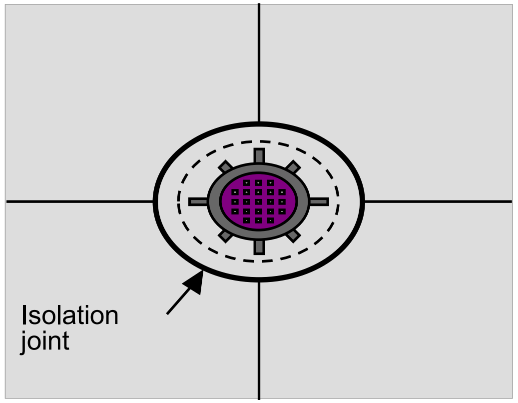
Common Details for Isolation of Fixtures



Square

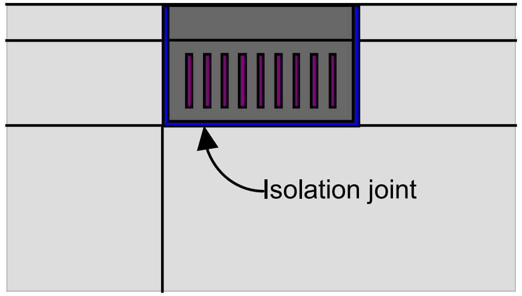


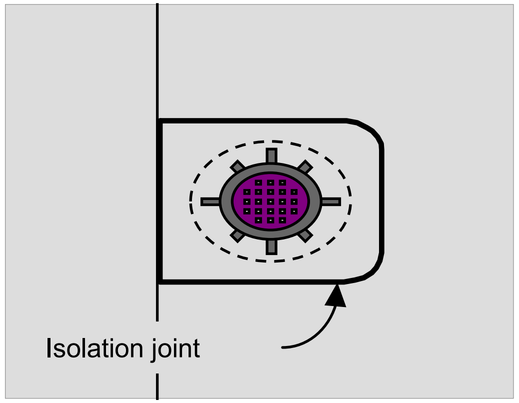
Diagonal



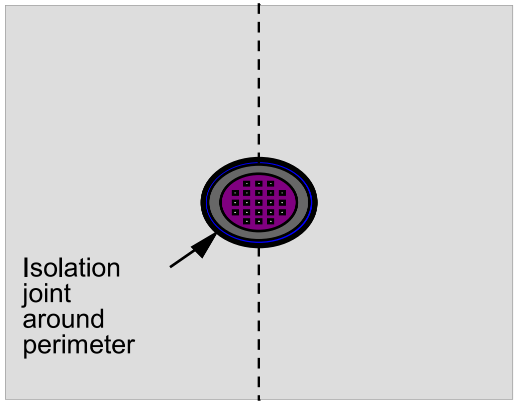
Circular

Inlet

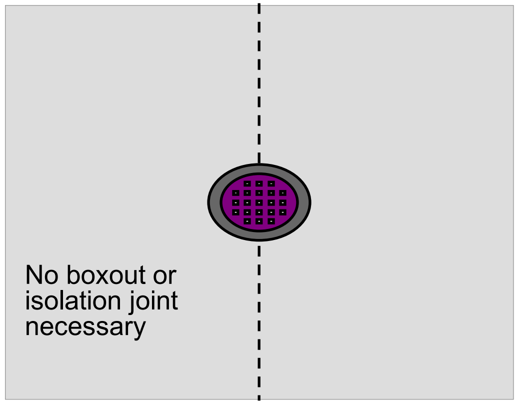




Square with Fillets

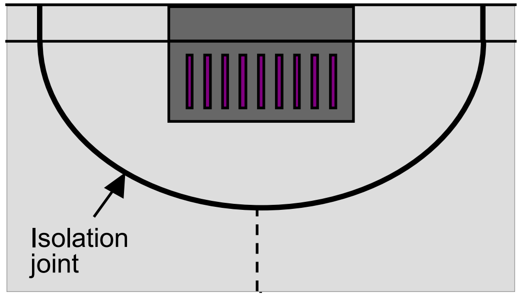


None

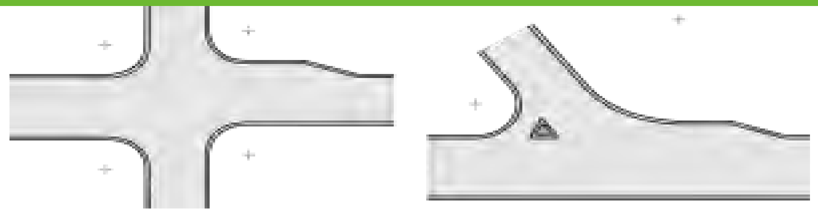


Telescoping Manhole

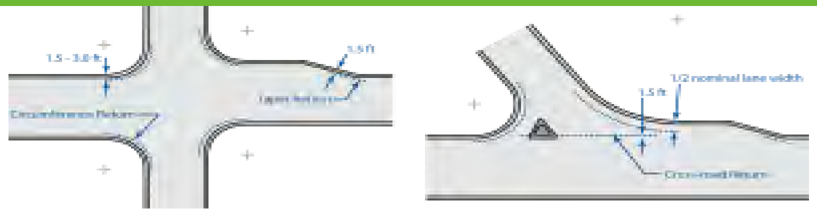
Inlet - Round



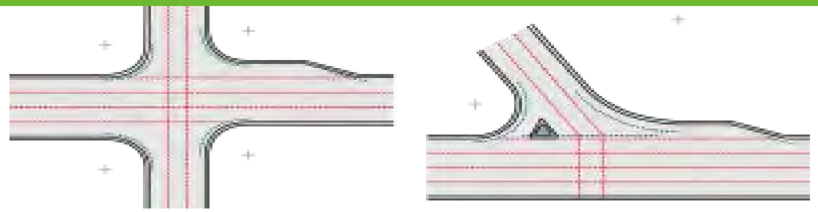
Jointing: Common Intersection – 10 Step Process



Step 1



Step 2



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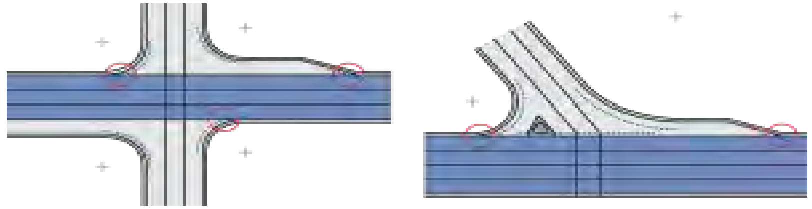

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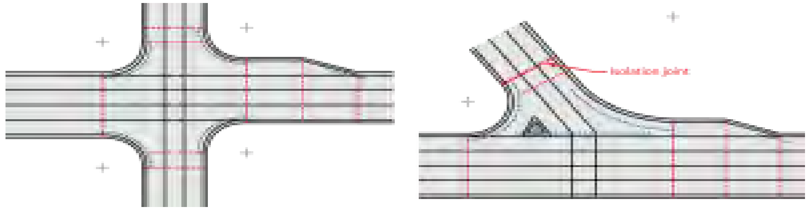

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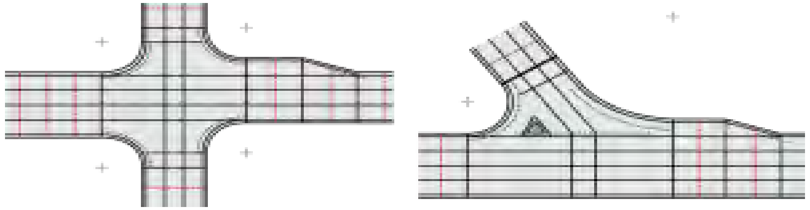

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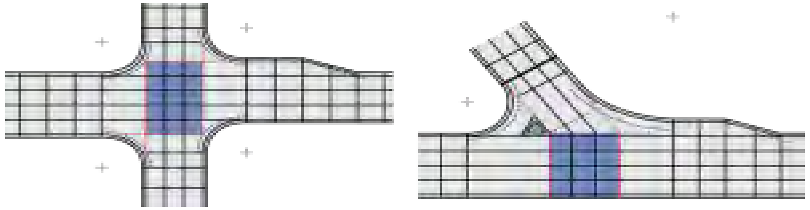

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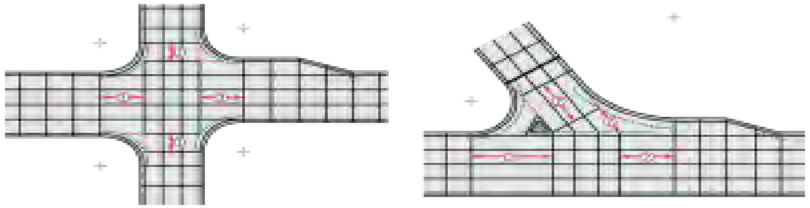

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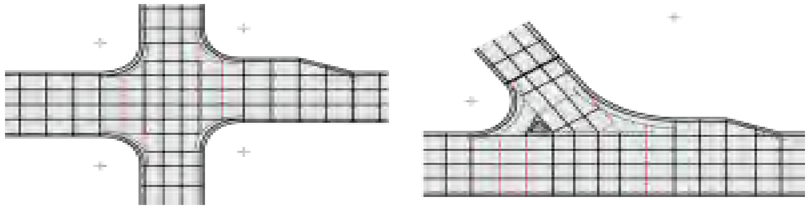

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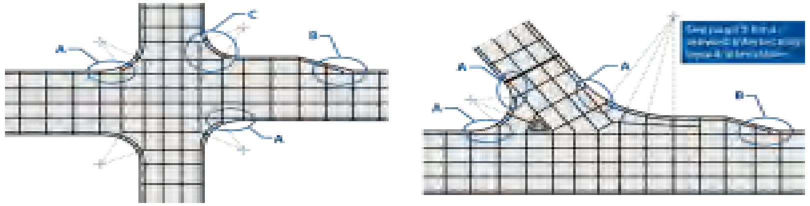

Step 10

Source: ACPA

PAVE AHEAD
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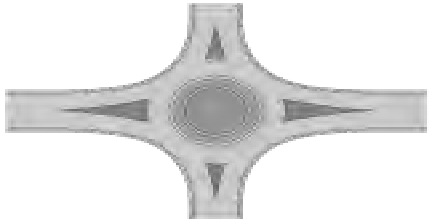
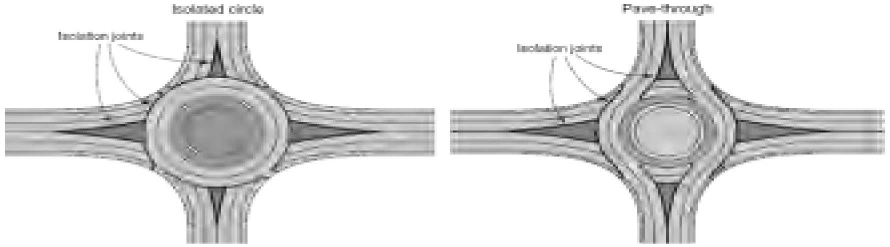
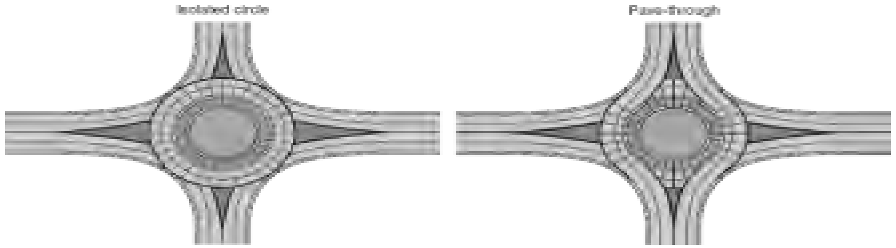
Jointing: Roundabouts – 6 Step Process


Step 1



Step 2



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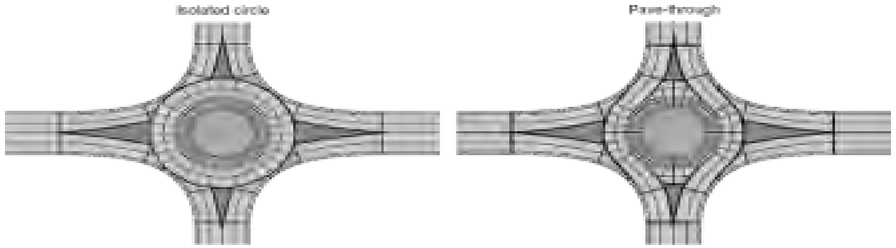
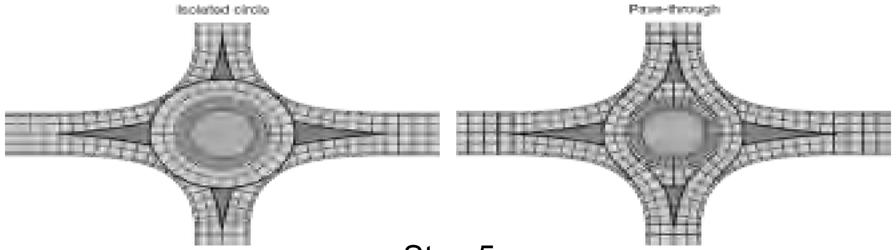


Step 4



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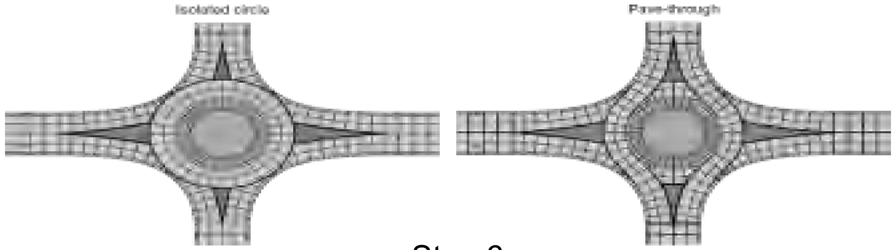

Step 6

PAVE AHEAD
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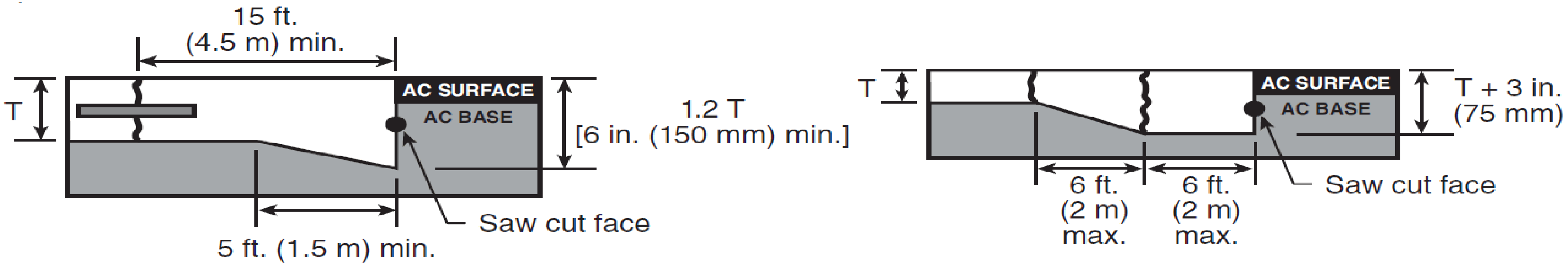
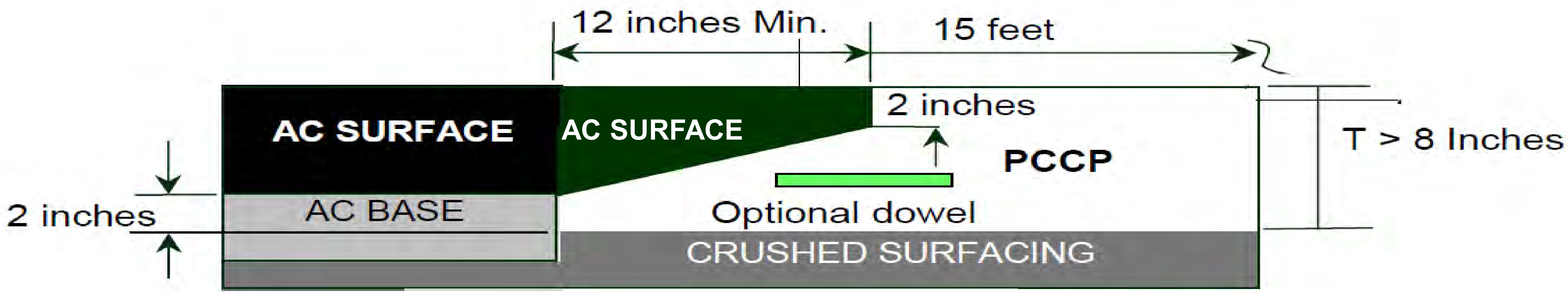
Source: ACPA

Asphalt to Concrete Transitions



Thickened Edge Transition (Doweled or Undoweled)



Impact Slab Transition for New Pavement

Detail Courtesy of ACPA



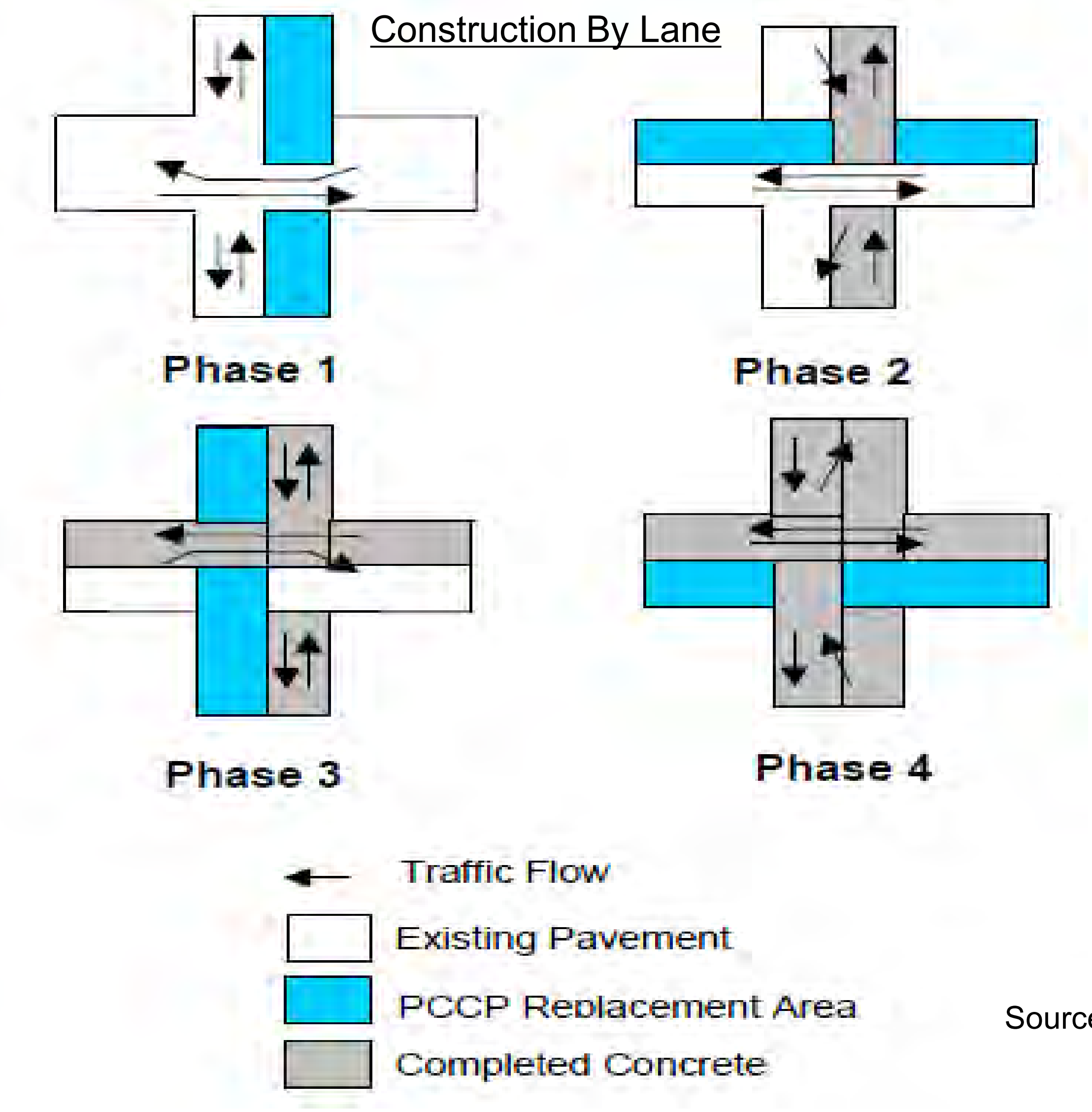
Concrete Intersections

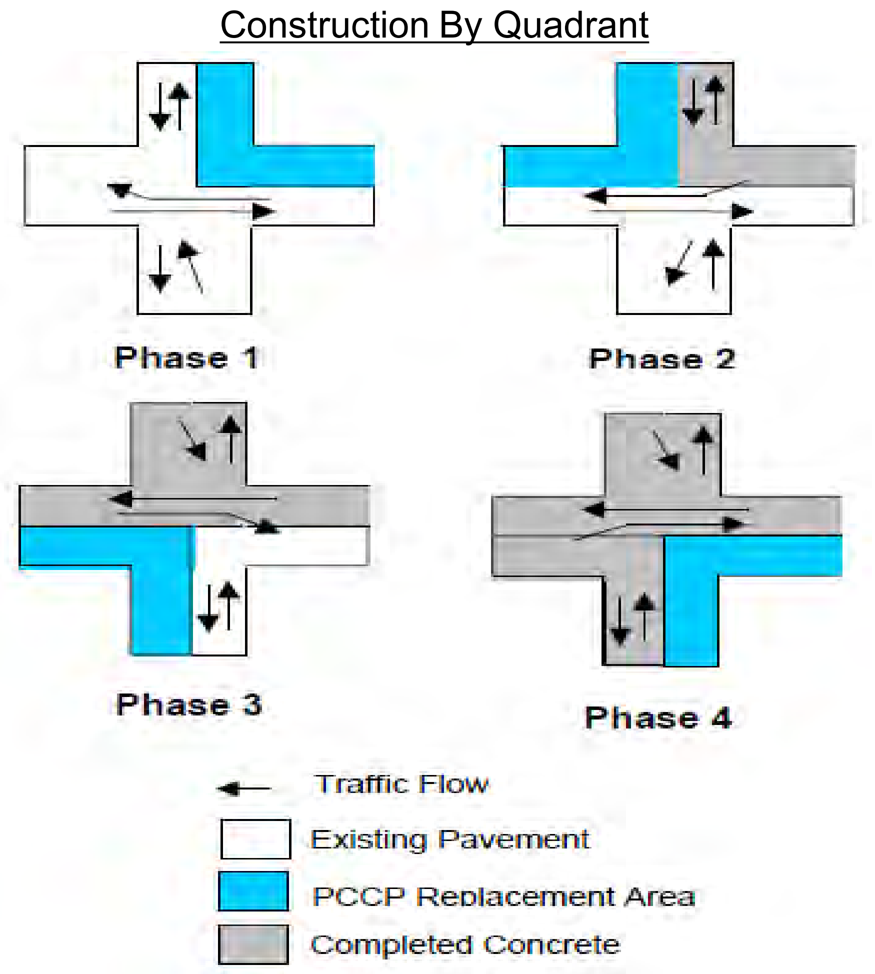
Maintenance of Traffic (Staging)


Maintenance of Traffic

- Options:
  - Complete closures with detours,
  - Partial closures with detours,
  - Construction under traffic,
  - Complete closures during limited time periods,
  - Combinations of the above.

Staging: Intersection Under Traffic





Source: ACPA

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Reconstruction SR 395 Kennewick, WA:

Under Traffic & Full Closure Over 3-Day Weekend

Concrete Intersections – Staging (Start)

Concrete Intersections – Staging (Stage 1 Under Traffic)

Concrete Intersections – Staging (Stage 2 Under Traffic)

Concrete Intersections – Staging (Stage 3 Under Traffic)

Concrete Intersections – Staging (Stage 4 Under Closure 3-Day Weekend)

3-Day Weekend Closure

- **Thursday evening to Friday morning**
  - 8:00 pm to 3:30 am – Remove existing surfacing
  - 3:30 am to 7:30 am – Grade, prep base
- **Friday Morning to Friday Evening**
  - 7:30 am to 9:00 pm – Form and pour concrete
  - 3:00 pm – Start joint sawing
- **Saturday Morning to Saturday Evening**
  - 6:30 am – Finish joint sawing
  - 8:00 am to 4:15 pm – Form and pour concrete
  - 4:30 pm to 8:00 pm – Asphalt approaches
  - 6:00 pm to 11:30 pm – Sawcut
- **Sunday Morning to Sunday Afternoon Evening**
  - 5:00 am to 9:00 am – Clean joints/blow dry
  - 9:00 am to 1:00 pm – Joint seal
  - 1:00 pm to 2:00 pm – Clean roadway
  - 2:00 pm to 4:45 pm – Prep roadway (striping)
  - 4:45 pm – Open to traffic

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Downtown Roseburg streetscape project

- OAK + WASHINGTON CORRIDOR
- CITY OF ROSEBURG
- SUMMER 2015

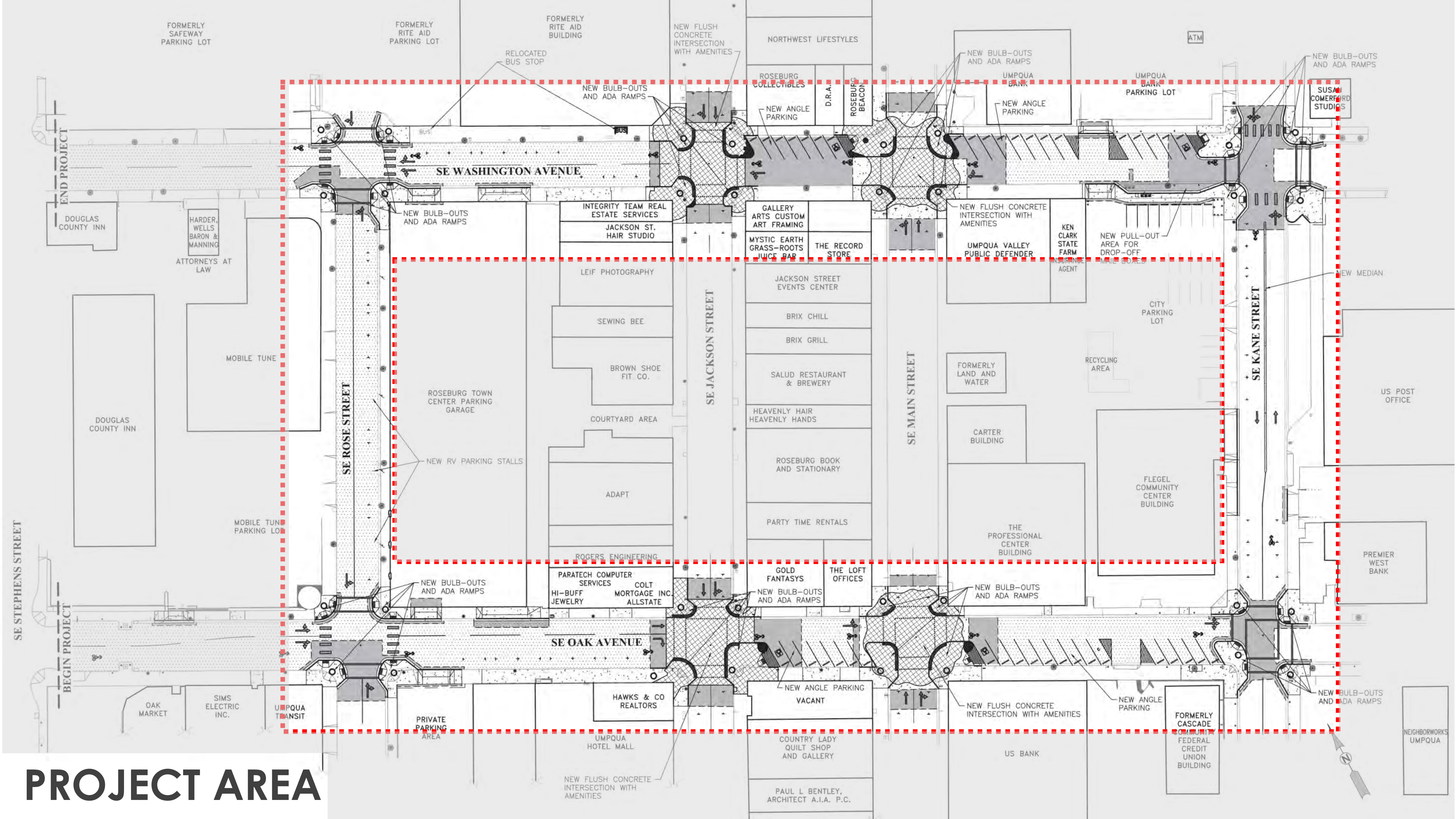
PRESENTED BY:

ALEX PALM + EMILY BRANDT

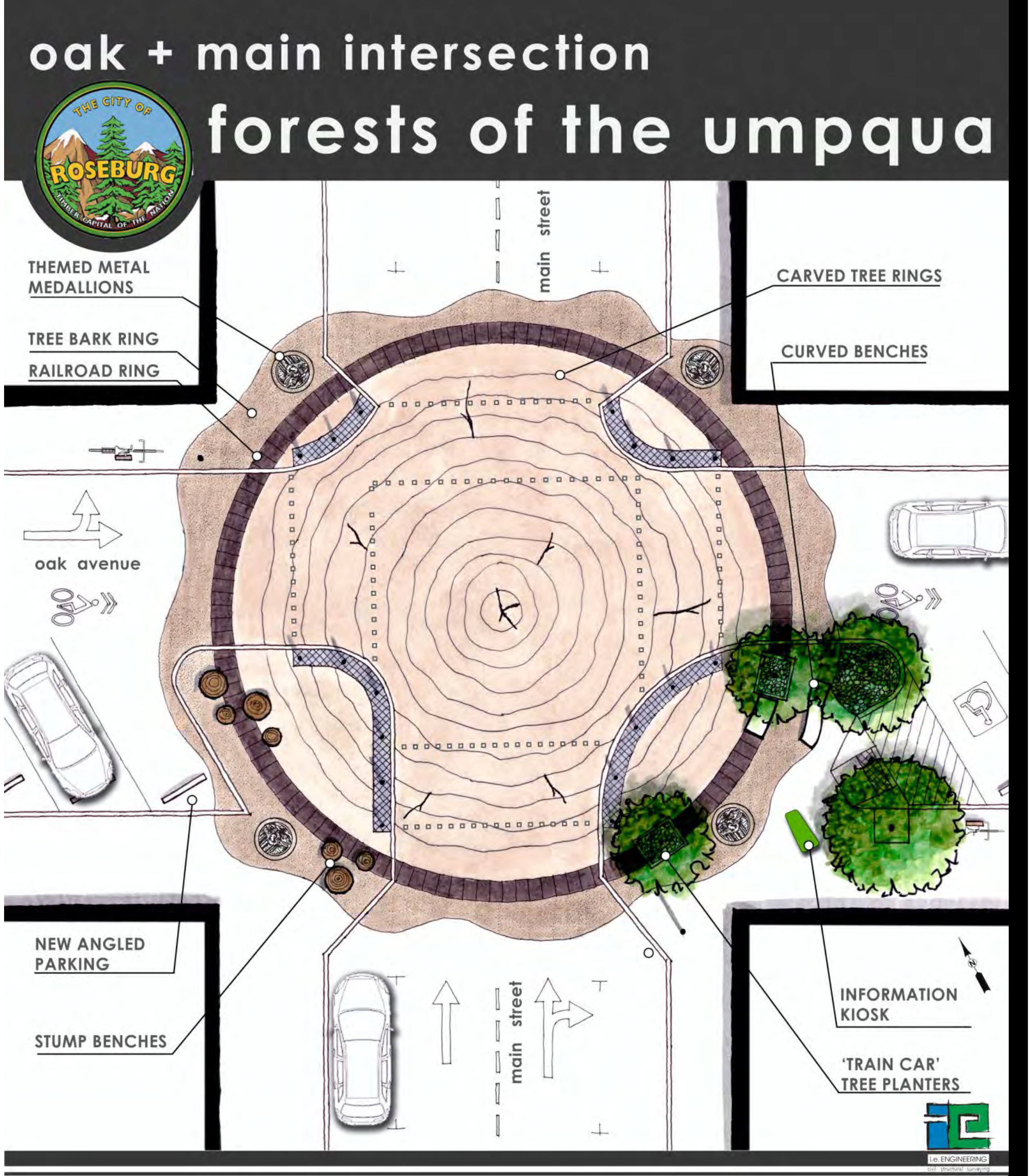
i.e. ENGINEERING

PAVE AHEAD

DURABLE. SUSTAINABLE. CONCRETE.



PROJECT AREA

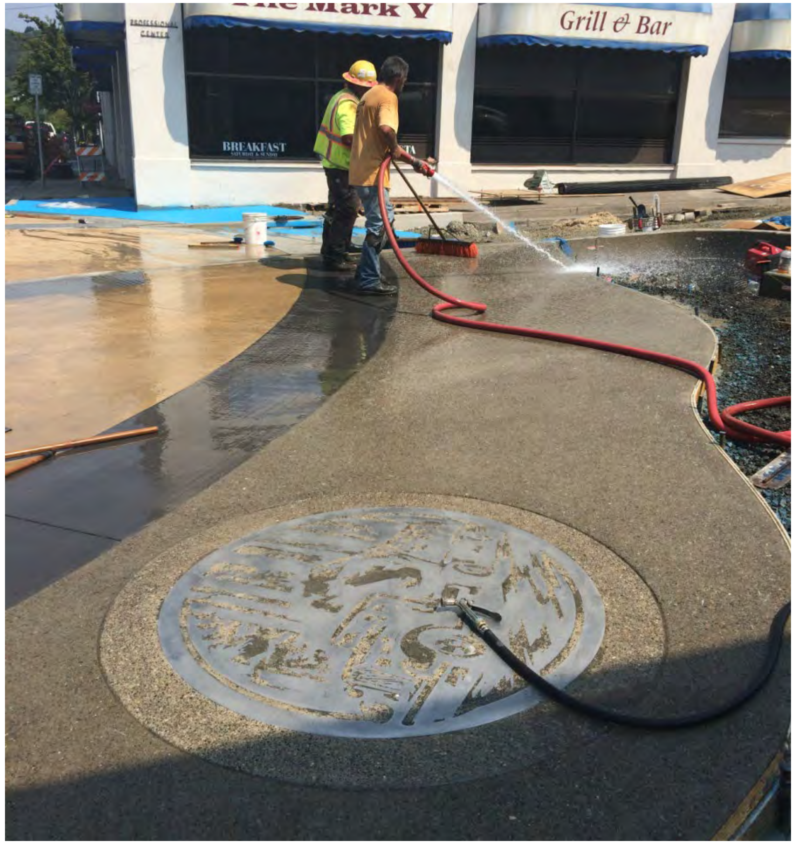


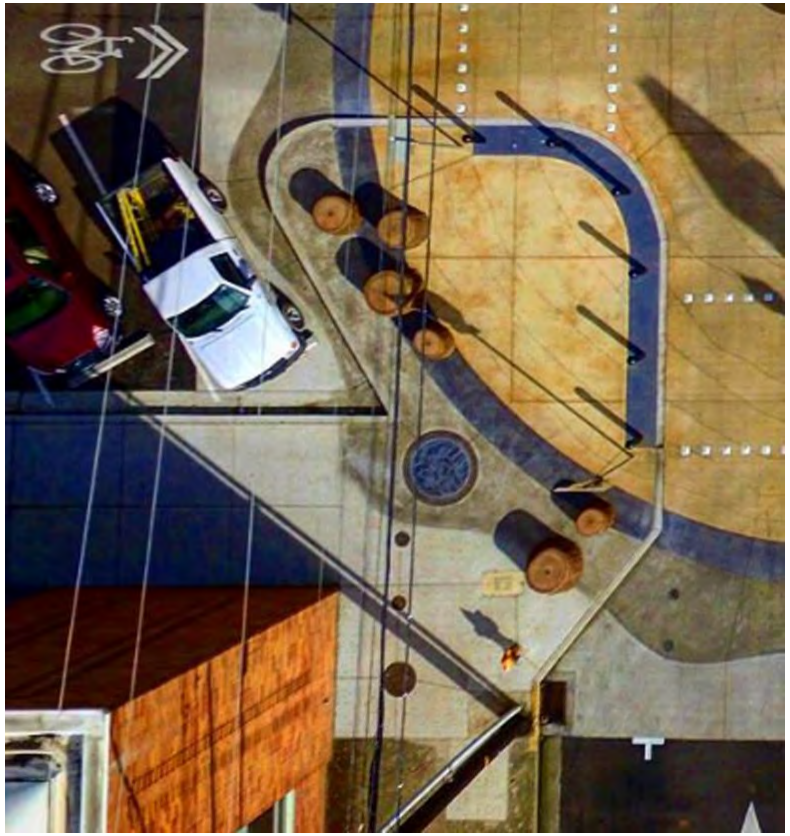
OAK + MAIN

FORESTS OF THE UMPQUA

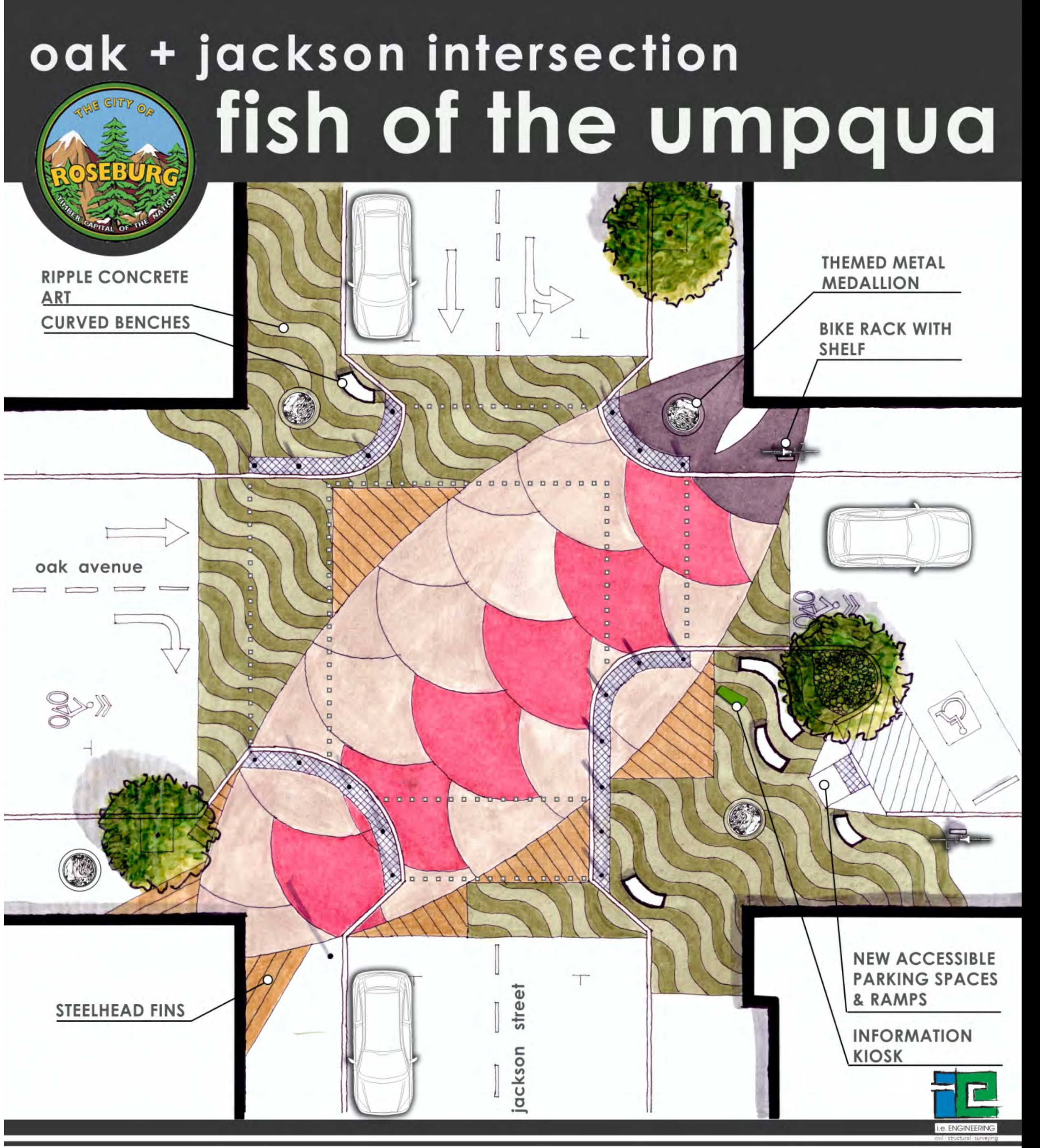
- EXPOSED AGGREGATE FINISH FOR TREE BARK (OUTER RING)
- BLACK INTEGRAL COLORED CONCRETE FOR THE RAILROAD TRACK RING, SCORED LINES FOR TRACK DETAIL
- BROWN INTEGRAL COLORED CONCRETE FOR THE INSIDE RINGS, RINGS SCORED AND DYED BLACK
- CONCRETE CURVED BENCHES
- DECORATIVE CONCRETE ‘STUMP’ BENCHES
- INLAYED DECORATIVE STAINLESS STEEL


The Mark V
Grill & Bar


The Mark V
Grill & Bar
BREAKFAST



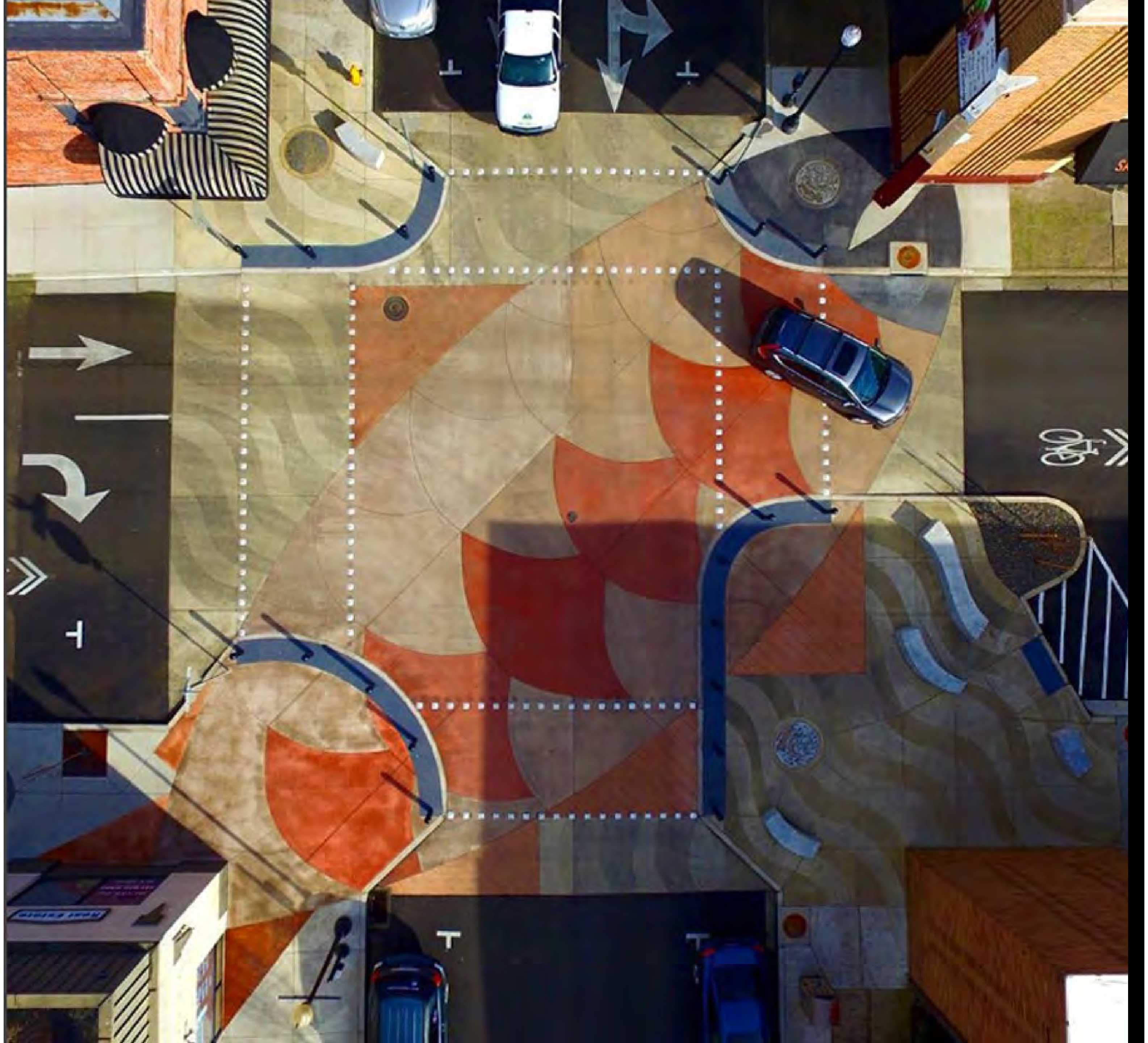

'STUMP' CONCRETE BENCHES

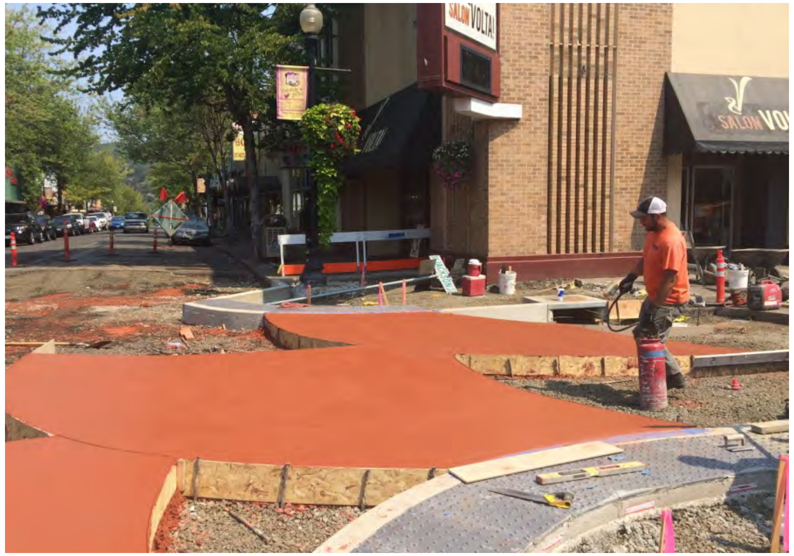


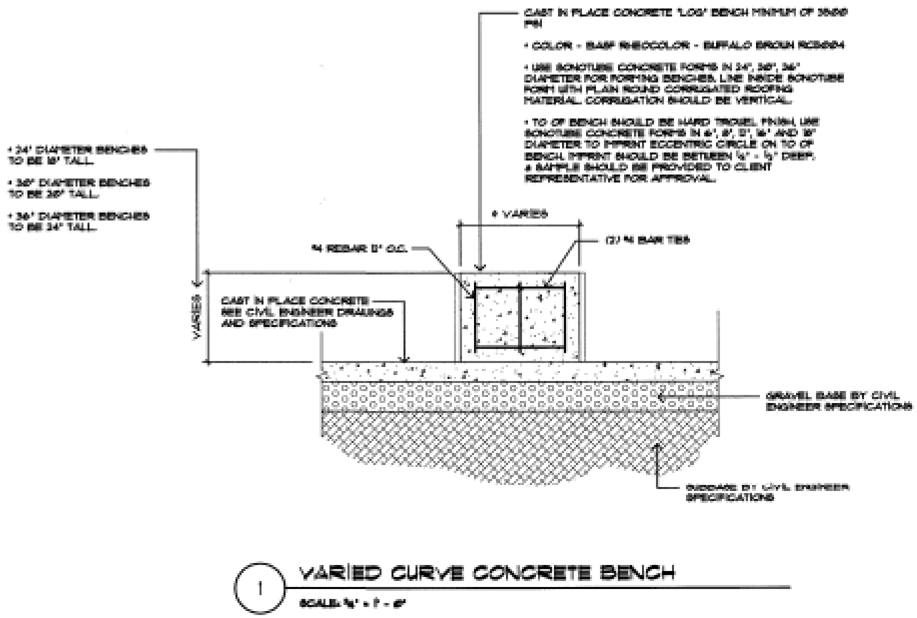
OAK + JACKSON

FISH OF THE UMPQUA

- EACH SCALE INDIVIDUALLY POURED
- BLACK INTEGRAL COLORED CONCRETE FOR THE FISH HEAD
- SANDBLASTED "RIPPLES"
- CONCRETE CURVED BENCHES
- SCORE MARKS FOR FIN LINES





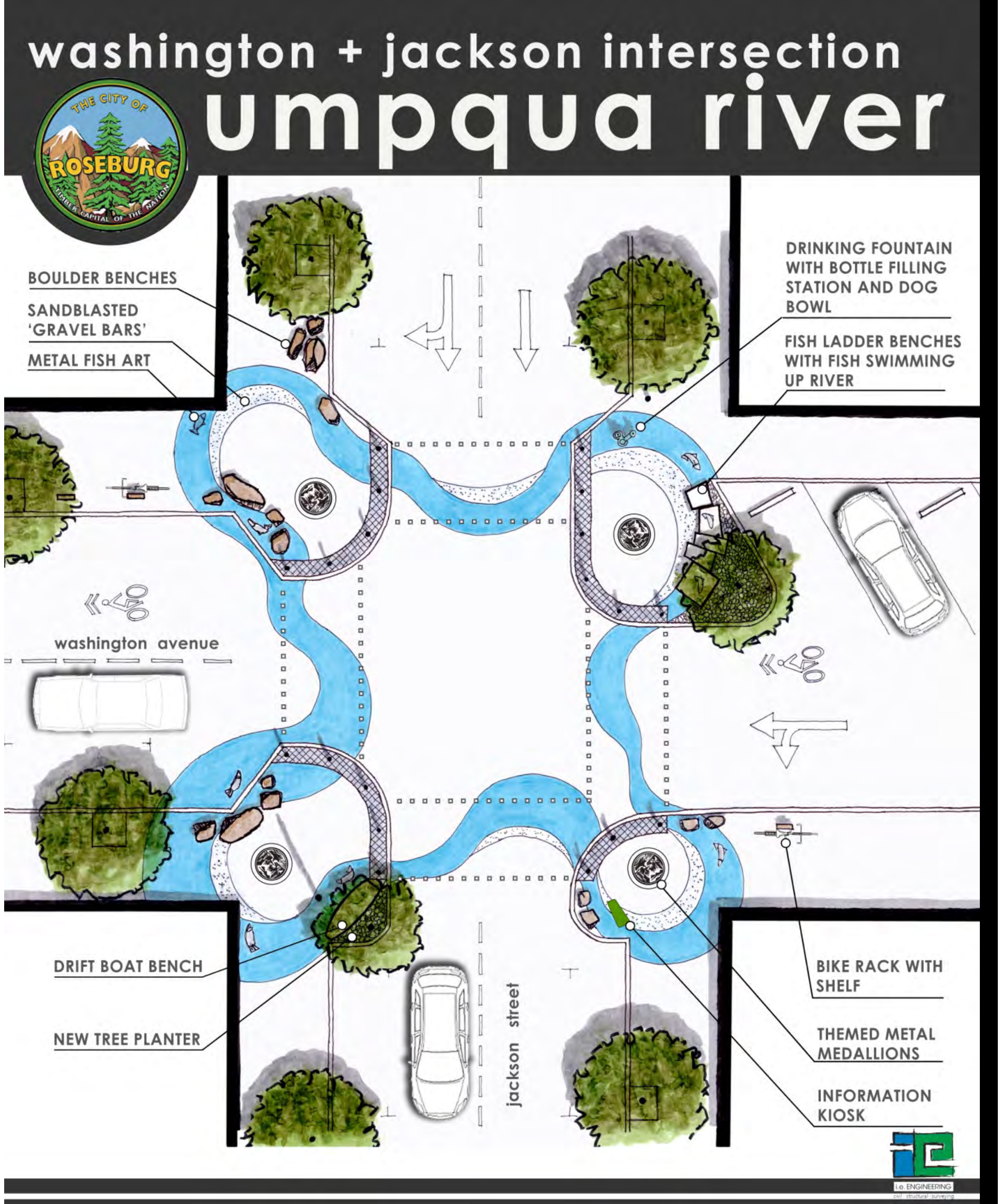


CAST IN PLACE CONCRETE "LOG" BENCH MINIMUM OF 3500 PSI
• COLOR - BASF RHEOCOLOR - BUFFALO BROWN RC8004
• USE SONOTUBE CONCRETE FORMS IN 24", 30", 36" DIAMETER FOR FORMING BENCHES. LINE INSIDE SONOTUBE FORM WITH PLAIN ROUND CORRUGATED ROOFING MATERIAL. CORRUGATION SHOULD BE VERTICAL.
• TO OF BENCH SHOULD BE HARD TROWEL FINISH. USE SONOTUBE CONCRETE FORMS IN 6", 8", 12", 16" AND 18" DIAMETER TO IMPRINT ECCENTRIC CIRCLE ON TO OF BENCH. IMPRINT SHOULD BE BETWEEN ¼" - ½" DEEP. A SAMPLE SHOULD BE PROVIDED TO CLIENT REPRESENTATIVE FOR APPROVAL.
• 24" DIAMETER BENCHES TO BE 18" TALL.
• 30" DIAMETER BENCHES TO BE 20" TALL.
• 36" DIAMETER BENCHES TO BE 24" TALL.
Ø VARIES
#4 REBAR 12" O.C.
(2) #4 BAR TIES
VARIES
CAST IN PLACE CONCRETE SEE CIVIL ENGINEER DRAWINGS AND SPECIFICATIONS
GRAVEL BASE BY CIVIL ENGINEER SPECIFICATIONS
SUBGRADE BY CIVIL ENGINEER SPECIFICATIONS
1
VARIED CURVE CONCRETE BENCH

WASHINGTON + MAIN

RECREATION IN THE VALLEY

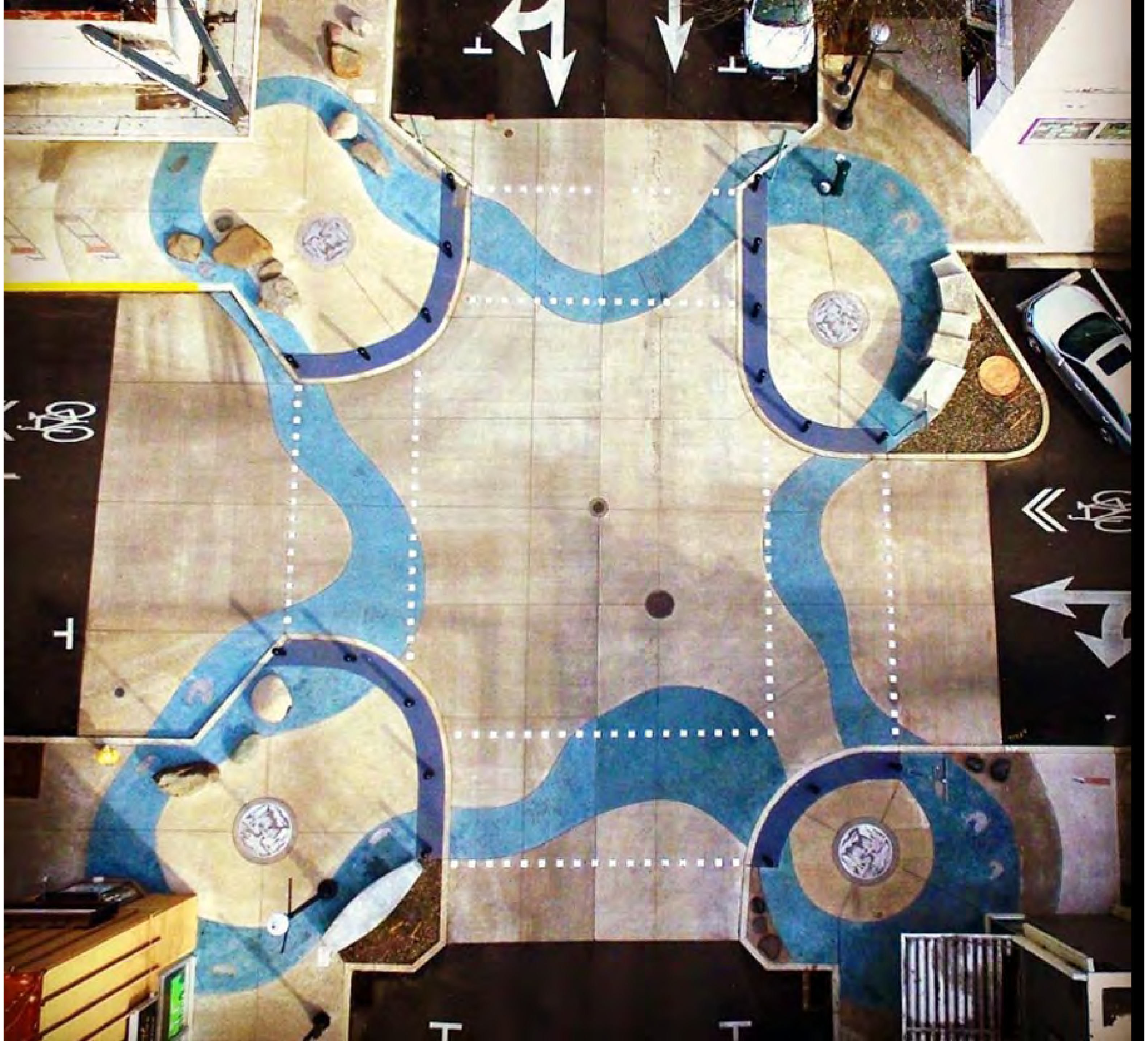
- REAL LEAF IMPRESSIONS
- BLACK INTEGRAL COLORED CONCRETE FOR THE BICYCLE WHEEL
- CURVED CONCRETE BENCHES
- SCORE LINES FOR BICYCLE SPOKES

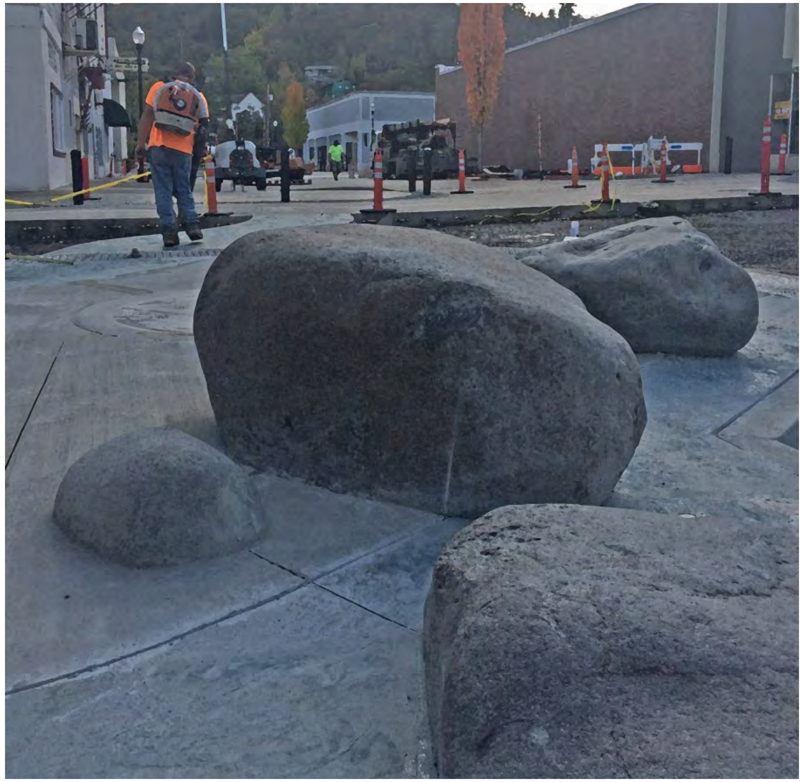


WASHINGTON + JACKSON

UMPQUA RIVER

- BLUE CONCRETE, 4" OF BLUE ON 4" OF GRAY
- STAMPED RIVER WITH SLATE DESIGN AND CLEAR RELEASE
- EXPOSED AGGREGATE FOR "RIVER SAND BARS"
- CONCRETE FISH LADDER BENCH
- INLAYED FISH
- POURED CONCRETE AROUND BOULDER BENCHES





Additional Resources

- http://safety.fhwa.dot.gov/intersection/innovative/roundabouts/
- www.Roundaboutsusa.com
- www.ACPA.org
- https://www.wsdot.wa.gov/research/reports/fullreports/503.2.pdf

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NRMCA Resources

How Can We Assist You for Free?

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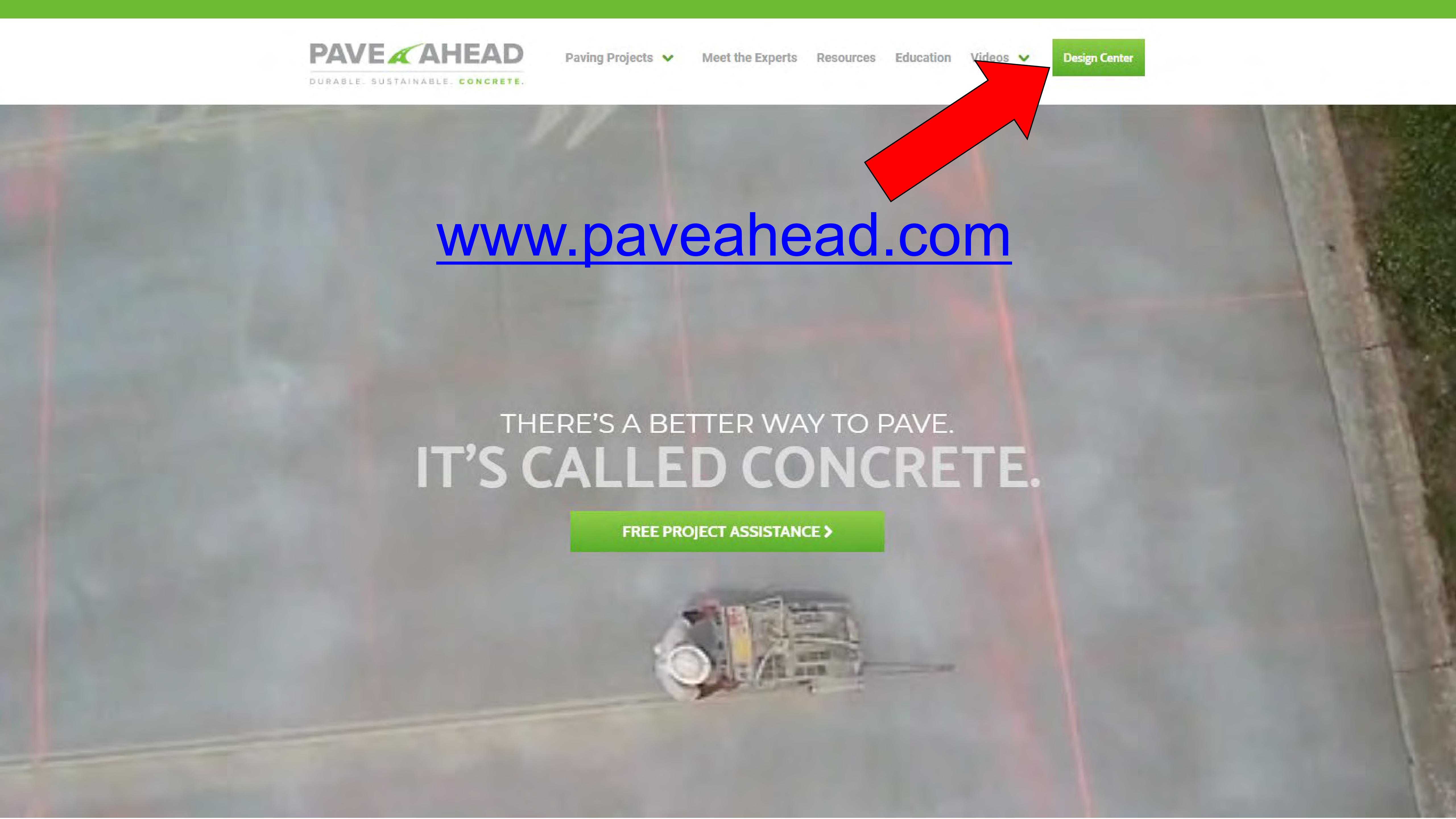
www.paveahead.com



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Pave Ahead™ Design Center

- Design and Jointing recommendations and reviews for FREE
- Cost comparisons including life cycle costs
- Specification review
- Ready mixed products:
  - Conventional concrete (full depth and overlays)
  - Pervious concrete
  - Roller compacted concrete
  - Cement slurry for full depth reclamation (FDR)

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Thank You!

www.nrmca.org/

paveahead.com/experts/

Questions???


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267-212-4700
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