

Concrete Pavement Options

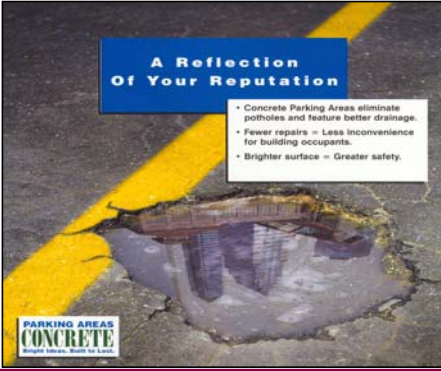


Matching Them to Your Needs!

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A Reflection Of Your Reputation



- Concrete Parking Areas eliminate potholes and feature better drainage.
- Fewer repairs = Less inconvenience for building occupants.
- Brighter surface = Greater safety.

**PARKING AREAS
CONCRETE**
Stronger. Smoother. Safer. Greener.

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The Possibilities

- Streets & Local Roads
- Parking Areas
- Commercial Applications
- Rest Areas
- Consider
 - Conventional
 - RCC
 - Pervious




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Benefits of Concrete Pavement

- Economical
 - Competitive construction costs
 - Fewer maintenance costs
 - Lower energy costs
 - Less lighting needed
 - Low heat absorption
 - lower cooling costs
- Lower Total Ownership Cost




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Benefits of Concrete Pavement

- Performance
 - Proven long life
 - Strength increases with age
 - No potholes
 - Evenly carries heavy loads




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Benefits of Concrete Pavement

- Maintenance
 - Low annual maintenance cost
 - Proven fewer repairs
 - No annual resealing needed
 - No business interruption





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Benefits of Concrete Pavement


- Safety
- Excellent light reflectance
- Greater visibility
- Rigid pavement means no ruts
- High skid resistance




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Benefits of Concrete Pavement


- Environmentally Friendly
 - Does not pollute waterways
 - Uses less raw materials
 - No hazardous materials used
 - Recycled materials can be used
 - Conserves petroleum resources



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Concrete Pavements Support Sustainable Development

- “Cool Communities”
 - Reduce Heat Island Effect
- LEED™ Certification
 - Concrete can assist in attaining necessary credits
- AIA Sustainable Development Goal
 - 50% reduction of use of fossil fuels in new construction by 2010

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Concrete vs. Asphalt

- Apples-to-apples comparison of pavement design should always be considered
- Quantification in \$ allows for a better business decision on pavement choice

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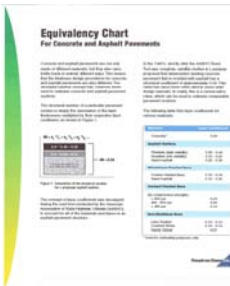
How Do We Achieve an Equivalent Design?


- By using structural layer coefficients
 - A relative number assigned for the value of 1” of pavement or base layer thickness
 - Using proper values is critical in order to achieve accurate output

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Structural Number

- Concrete = 0.50
- Surface Asphalt = 0.20 to 0.44
- Bituminous Base = 0.10 to 0.34
- Aggregate Base = 0.07 to 0.14



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For Example:

- 5" Concrete Pavement
- 5" X 0.50 = 2.50 SN


- 1.5" Surface Asphalt & 6" of Bituminous Base
- 1.5" X 0.38 = 0.57
- 6.0" X 0.32 = +1.93
- 2.50 SN

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Concrete Pavement Analyst

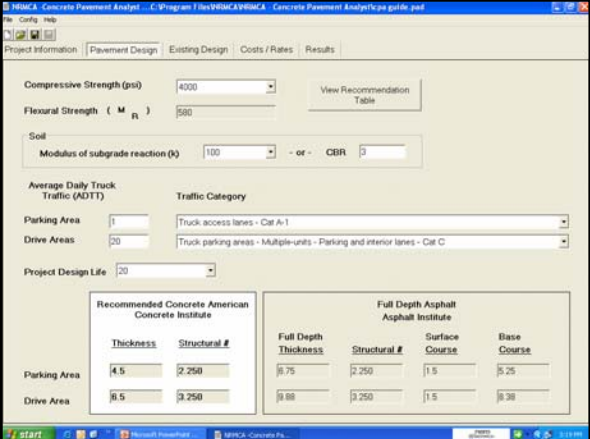
- Compares Asphalt and Concrete designs per industry standard specifications
- Allows user to make a more educated decision

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Concrete Pavement Analyst
Parking Area Design and Costing Software
Version 1.1
Copyright 2004
Count on Concrete

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Concrete Pavement Analyst - C:\Program Files\WBKAV\WBKCA - Concrete Pavement Analyst\cpa.prtic.psd

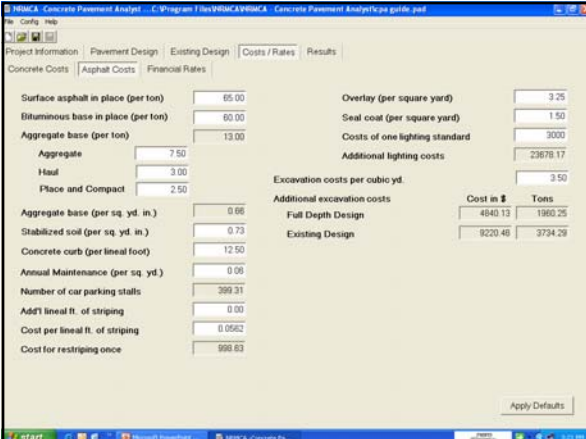
Project Information | Pavement Design | Existing Design | Costs / Rates | Results

Compressive Strength (psi): 4000
Flexural Strength (M R): 580
Soil Modulus of subgrade reaction (k): 100 - or - CBR: 2

Average Daily Truck Traffic (ADTT):
Parking Area: 1 | Traffic Category: Truck access lanes - Cat A-1
Drive Areas: 20 | Truck parking areas - Multiple-units - Parking and interior lanes - Cat C

Project Design Life: 20

	Recommended Concrete American Concrete Institute		Full Depth Asphalt Asphalt Institute			
	Thickness	Structural #	Full Depth Thickness	Structural #	Surface Course	Base Course
Parking Area	4.5	2.250	6.75	2.250	1.5	5.25
Drive Area	6.5	2.250	8.88	2.250	1.5	6.38



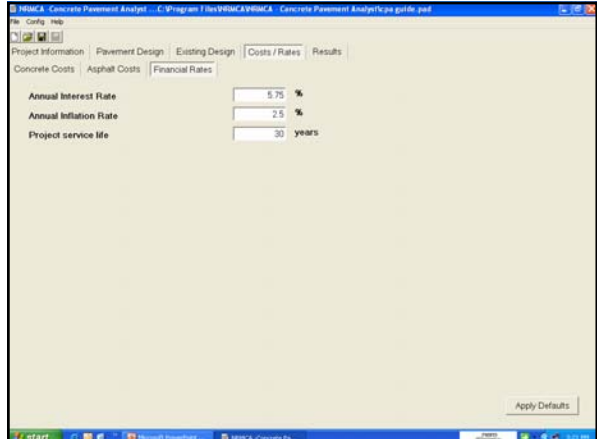
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Project Information | Pavement Design | Existing Design | Costs / Rates | Results

Concrete Costs | Asphalt Costs | Financial Rates

Surface asphalt in place (per ton)	65.00	Overlay (per square yard)	3.25
Bituminous base in place (per ton)	60.00	Seal coat (per square yard)	1.50
Aggregate base (per ton)	13.00	Costs of one lighting standard	3000
Aggregate	7.50	Additional lighting costs	23876.17
Haul	3.00	Excavation costs per cubic yd.	3.50
Place and Compact	2.50	Additional excavation costs	Cost in \$ Tons
Aggregate base (per sq. yd. in.)	0.66	Full Depth Design	4840.13 1960.25
Stabilized soil (per sq. yd. in.)	0.73	Existing Design	9220.46 3734.29
Concrete curb (per lineal foot)	12.50		
Annual Maintenance (per sq. yd.)	0.06		
Number of car parking stalls	399.31		
Add'l lineal ft. of striping	0.00		
Cost per lineal ft. of striping	0.0562		
Cost for restriping once	998.63		

Apply Defaults



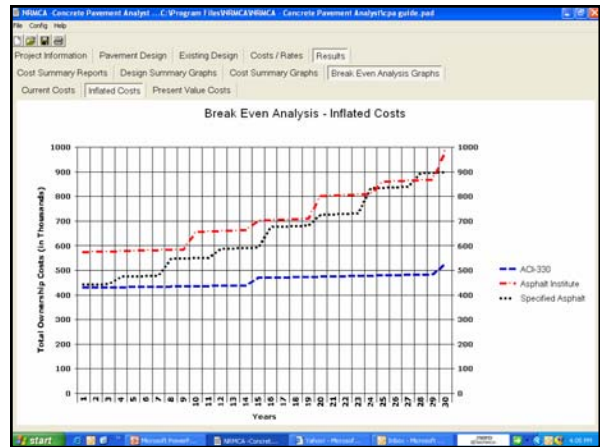
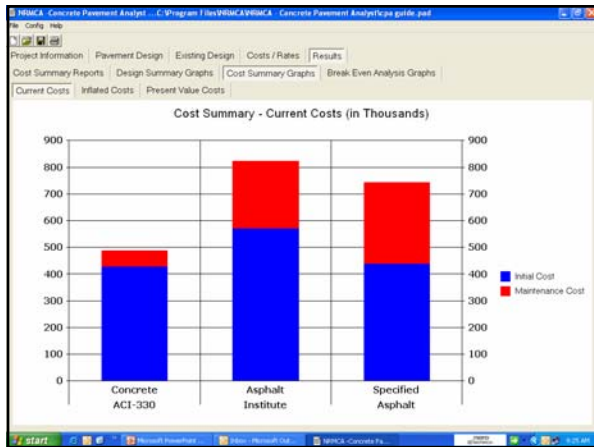
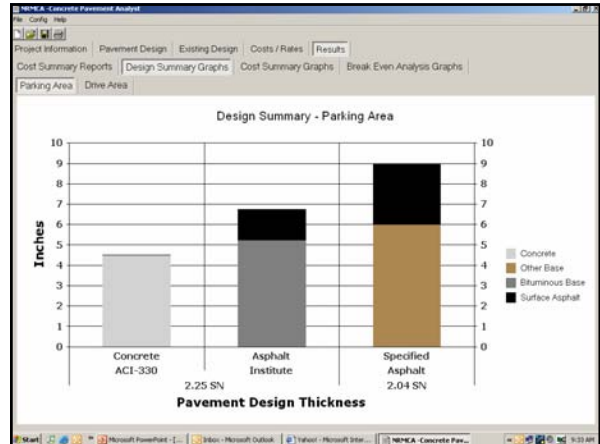
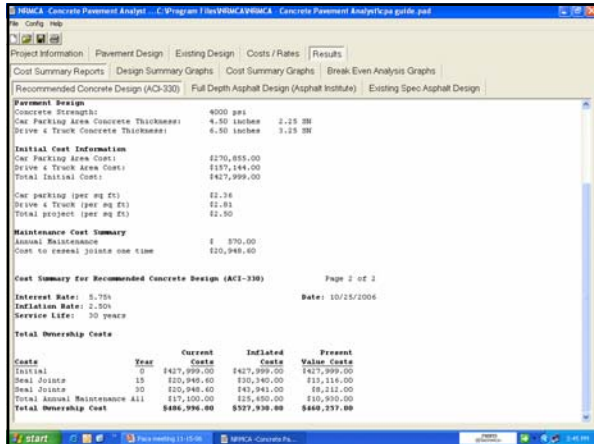
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Project Information | Pavement Design | Existing Design | Costs / Rates | Results

Concrete Costs | Asphalt Costs | Financial Rates

Annual Interest Rate	5.75 %
Annual Inflation Rate	2.5 %
Project service life	30 years

Apply Defaults



High Truck Traffic? Heavy Loadings?

Roller Compacted Concrete

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Definition

“Roller-Compacted Concrete (RCC) is a non-slump concrete that is compacted by vibratory rollers.”

- Zero slump (consistency of damp gravel)
- No forms
- No reinforcing steel
- No finishing
- Consolidated with vibratory rollers

Concrete pavement placed in a different way!

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Benefits of RCCP

- Fast construction with minimum labor
- High load carrying ability
- Early strength gain
- Durable
- Low maintenance
- Light surface reduces lighting requirements
- Economical

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Highway
Interchanges

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Project Considerations

- Project size
- Site geometry
- Loading characteristics
- End use
- Client expectations



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Highway
Interchanges

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Port Terminals



Norfolk International Terminal, VA

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Parking Areas



134 acre parking facility at Saturn plant, TN

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Streets & Interchanges



Residential Street Columbus, OH

Residential
Highway
Interchanges

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Highway Shoulders



I-285 Highway Atlanta, GA

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Distribution Centers



Liberty Property Trust - Lewisberry, PA

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Surface Appearance

- Not as smooth as conventional concrete
- Important to recognize difference
- Similar appearance to asphalt only light grey instead of black



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Mixture Design


- Dry enough to support vibratory roller
- Wet enough to permit adequate distribution of paste



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Mixture Design

- Differs from conventional concrete pavements
 - Not air-entrained
 - Lower water content
 - Lower paste content
 - Larger fine aggregate content
 - Nominal max. size aggregate +/- 5/8 in.

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Typical Design


- 400 – 600 lb/cy cementitious material
- 3,400 – 3,700 lb/cy combined aggregate
 - 1,700 – 2,200 lb/cy coarse aggregate
 - 1,300 – 1,700 lb/cy fine aggregate
- 170 – 250 lb/cy water (20 -30 gallons)
- W/C ratio usually between 0.3 -0.45

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Continuous Pug Mill


- High-volume applications
- Excellent mixing efficiency for dry materials
- 250 to 500+ tons/hr
- Mobile, erected on site




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Central Mix Plant


- Highly accurate proportioning
- Local availability
- Smaller output capacity
- Longer mix times than conventional concrete
- Frequent cleaning
- Dedicated production



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Transporting


- Rear dump trucks normally used
- Minimize transport time
- Covers required for long hauls, or hot/windy conditions



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Placing


- Layer thickness
 - 4 in. minimum
 - 8 in. maximum (10 in. with heavy-duty pavers)
- Timing sequence
 - Adjacent lanes placed within 60 minutes for "fresh joint", unless retarders used
 - Multiple lifts placed within 60 minutes for bond
- Production should match paver capacity
 - Continuous forward motion for best smoothness

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Placing Equipment

- High-density concrete
 - Vibrating screed
 - Dual tamping bars
 - High initial density, 90-95%
 - Reduces subsequent compaction
- High-volume placement (1,000 to 2,000 cubic yards per shift)
- Designed for harsh mixes
- Smoothest RCC surface



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Placing Equipment

- Conventional asphalt pavers
 - Provide some initial density (80-85%)
 - Relatively smooth surface
 - May require modification
 - Increased maintenance




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Compaction


- Proper compaction is critical for strength and durability
- Compact to 98% Modified Proctor
- Vibratory roller
- Rubber-tire roller




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Construction Joints

- Most critical area of project
- Must be constructed properly for durability
- Ensures bond/interlock, so slab acts monolithically
- Three types of construction joints:
 - "Fresh joints"
 - "Cold joints"
 - "Horizontal joints"

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Fresh Joint



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Edges Critical

- Compaction more difficult
- Segregation more likely
- Try to minimize number of cold joints
- Care needed to match grade from cold to fresh joint

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Edge Compaction




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Cracking/Jointing


- Saw-cut joints unnecessary for performance
- Natural cracks typically provide adequate load transfer
- Saw-cut joints control cracks for aesthetic purposes




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Natural Cracks


- Most economical
- 15 to 60 ft spacing
- Often first cracks appear within 24 hours
- Narrow crack widths
- Seal if > 1/4 in.
- Provide load transfer
- Minimal raveling



New, Unsealed Crack





10-yr Old Sealed Crack

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Saw-Cut Joints


- More aesthetically pleasing
- Soff-cut very effective, shortly following placement
- Need to saw within 12 hours to avoid uncontrolled cracking
- 1/3 to 1/4 depth
- Seal joints similar to conventional concrete





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Curing


- EXTREMELY IMPORTANT
- Ensures surface durability; reduces dusting
- Low moisture content in RCC; no bleed water
- Three methods:
 - Moist cure
 - Concrete curing compound
 - Asphalt emulsion

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Moist Cure







Typically 7-day specified

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Curing Compound


- White-pigmented concrete curing compounds
- Application rate depends on surface texture





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Asphalt Emulsion

- Excellent moisture barrier
- Common compounds: SS-1, RC-250, MC-250
- Clean surface if needed
- Moisten surface
- Apply at 0.15 to 0.30 gal/sy
- Good for asphalt cap



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Surface Texture




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Storm Water Runoff Problems?

Pervious Concrete

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What is Pervious Concrete?

- A No-Fines Concrete Mix
 - Coarse Aggregate
 - Portland Cement
 - Water
- Intended for use as an open-graded drainage material




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Why Pervious Concrete?

- Storm Water Control
 - “First Flush”
 - 90% of surface pollutants washed off pavement
 - Detention/Retention Ponds
 - Unusable ground
 - \$\$\$\$\$
- Pollution treatment
- Recharges the aquifer
- Sustainable Construction
 - LEED
 - “Cool Communities”



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Why Pervious Concrete?

Safety




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Pervious Concrete Implications On the LEED Rating System

- Sustainable Sites
 - Credit 6.1 Storm Water Management (1 Pt)
 - Credit 7.1 Heat Island Effect: Non-Roof (1 Pt)
- Water Efficiency
 - Credit 1.1 Water Efficient Landscaping (1 Pt)
 - Credit 3.1/3.2 Water Use Reduction (1 Pt)


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Pervious Concrete Implications On the LEED Rating System

- Materials & Resources
 - Credit 4.1/4.2 Recycled Content (1 Pt)
 - Credit 5.1/5.2 Local/Regional Materials (1 Pt)
- Total Possible Points
 - Sustainable Sites (2 Pts)
 - Water Efficiency (2 Pts)
 - Materials & Resources (2 Pts)

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Parking Lots




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Tree Wells



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Driveways



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Sidewalks



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Nature Paths



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Pervious Concrete Mix

- Cement
 - Type I
 - 450-650 lbs./yard
 - Some mixes have incorporated fly ash or slag
- Coarse Aggregate
 - 3/8" stone (may use larger, more open surface, ADA compliant)
 - 2000 – 2600 lbs./yard

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Pervious Concrete Mix


- Water
 - Potable
 - W/C Ratio 0.27-0.34
- Admixtures
 - Accelerators/retarders have been used
 - Air entrainment

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Properties of Pervious Concrete


- Very low slump (1" or less)
- 15% to 35% air void content
- 100 to 120 lbs/ft³ unit weight
- 500 to 3000 psi strength*
 - Compressive strength typically *not* used as acceptance criteria. Air void structure and unit weight are used instead.
- Drainage rate = 2 to 18 gal/min/ft²



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Design Considerations

- Hydraulic
 - Expected rainfall
 - Permeability of the sub-grade
 - Percolation rate ½" per hour
 - 100% "drain down" not to exceed 5 days
 - Storage capacity of base material
 - Porosity
 - Depth
 - Grade as flat as possible (0%-1% slope)

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Design Considerations


- Structural
 - ACI 330R-01 (Guide for Concrete Parking Lots)
 - Typical 6" , if occasional truck traffic 8"

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Maintenance


- Pervious may require periodic cleaning to keeps "pores" open
- Cleaning may be facilitated with a power washer or vacuum assisted sweeper
- Use of chemical cleaners not recommended



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Maintenance

- Snow/Ice removal
 - Deicing chemicals not recommended
 - Mechanical removal should employ small snow blowers or light plows
 - Plow should be fitted with rubber/plastic shield


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General Issues

- Durability
 - Iowa State University Studies
 - Penn State Welcome Center
 - Sidewalk, about 9 years old
- Cost
 - In general about the same as standard concrete




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Questions?

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Utility Cut Issues?


Flowable Fill

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What is Flowable Fill?

- DEFINITION* - Flowable Fill is a self compacting, cementitious material used primarily as a backfill material in lieu of compacted-soil backfill.



- *Defined in ACI 229R-94.


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Flowable Fill History


- Over 20 years old
- Developed as a solution to settlement of poorly compacted soil or granular fill
- Essentially large amounts of fly ash and water
 - Volume reduction issues
- Research has led to development of stable mixes and a variety of uses

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What Is a Flowable Fill Mix?

- Main Ingredients:
 - Cement
 - Sand
 - Water
 - with
 - Fly Ash
 - GGBF Slag
 - Stable Air Generators



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Properties of Flowable Fill

QuickTime™ and a decompressor are needed to see this picture.

- High Slump
- (9" +/-)
- Low Strength
- Commonly 100 PSI in 28 days

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Flowable Fill is **NOT** Concrete

- Similarity ends with delivery vehicle
- Low cementitious
- Does not hydrate
- Settles, dewater
- The wetter the better
 - Less water does not equate to faster hardening
 - Too little water will not allow proper settlement

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Therefore . . .

- Specification offers
 - Flexibility of design
 - Minimal mix design testing
 - Little or no field testing required

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● Typical Flowable Fill Mix

- Portland Cement 35-75#
- Fly Ash 300 – 400#
- Sand (+/-) 2600#
- Water 415 – 460#
- Air % 6%

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PennDOT Specification – Section 220

Properties & Criteria	Type A	Type B	Type C	Type D
Mix Design CY Cement Pozzolans Bottom Ash*	45 lbs 910 lbs 0 lbs	23 lbs 136 lbs 1180 lbs	68 – 90 lbs 136 lbs 1180 lbs	136 – 320 lbs 45 – 180 lbs
Slump	7" min.	7" min.	7" min.	7" min.
Density	N/A	N/A	N/A	30 – 70 pcf
Water Absorption	--	--	--	20% max
Compressive Strength	125 psi max	125 psi max	800 psi min.	90 – 400 psi

* Bottom Ash or Coarse Agg or Fine Agg or Air Generating Admixture

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Compacted-Soil Backfill Concerns

- Lack of Compaction -- Causes most call-backs to repair settlement problems.
- Improper backfill is the number one complaint of public works directors.
 - * "How to Get Utilities to Repair Streets Right", Better Roads, April, 1990
- Study indicates that 65% of utility cut restorations were unsatisfactory.
 - * "Utility Cut Restoration", Metropolitan Toronto Roads And Traffic Department, April 1985

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Other Concerns

- Compaction around pipes for support.
- Number of compaction lifts:
 - Increases project construction time.
 - Continuous testing.
 - Requires continuous inspection.
 - Safety of workers.
- Moisture content.
- Storage of materials on site.
- Inconsistent soil test results.

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Benefits of Flowable Fill

- Reduced in-place costs
 - less labor & equipment
- Minimized settlement
- Easily removable
- Versatile

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Benefits of Flowable Fill

- Year-round availability
- No compaction required
- Self leveling
- Increased worker safety
- Can Be color-coded for utility identification

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Flowable Fill Saves Money

Labor Costs for Placing Granular Fill

■ Placement	\$73.98*
○ (2 laborers @ 36.99/hr*)	
■ Compaction	\$73.98*
○ (2 laborers @ 36.99/hr*)	
■ Heavy Equip. Operator	\$40.34*
■ Hand Compactor	\$15.00*
■ Backhoe	\$25.00*
■ Total labor*	\$228.30

* National Industry Average incl. overhead costs

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Flowable Fill Saves Money


● Labor Costs for Placing Flowable Fill

■ Placement	\$36.99
■ Compaction	n/a
■ Heavy Equipment	n/a
○ Total labor for Flowable Fill	\$36.99
○ Total labor for Granular Fill	\$228.30

● Labor savings www.pacaweb.org \$191.31

Flowable Fill Applications


- Backfill
 - Where speed of construction is advantageous and where better performance is required.
 - Ideal for use in tight or restricted areas where placing soil fill is difficult.
 - Trenches — utilities, primarily roadways
 - Bridge abutments
 - Pipe bedding
 - Building excavations
 - Wet conditions




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Flowable Fill Applications


- **Structural Fill**
 - Road base
 - Mud jacking
 - Sub footing
 - Floor slab base




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Flowable Fill Applications

- **Environmental**
 - Abandoned sewers, tanks, pipe, etc.
 - Environmental remediation
 - Slope stabilization



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Flowable Fill May Be Excavated with Conventional Equipment



- 100 PSI flowable fill can be excavated with backhoe
- Can also be dug with pick and shovel

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