GUIDELINE FOR ASPHALT PAVEMENT DESIGN IN COLORADO

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GUIDELINE FOR ASPHALT PAVEMENT DESIGN IN COLORADO

- Outline
  - Subgrade Investigation
  - Laboratory Testing
  - Determination of Subgrade Design Strength
  - Subgrade Preparation
GUIDELINE FOR ASPHALT PAVEMENT DESIGN IN COLORADO

 Outline

– Design Traffic
– Pavement Design Equation
– Design Thickness
– Asphalt Mix Selection
– Recent/New Technologies
GUIDELINE FOR ASPHALT PAVEMENT DESIGN IN COLORADO

- Developed by the Colorado Association of Geotechnical Engineers (CAGE)
- Under the Request and Assistance from the Colorado Asphalt Pavement Association (CAPA)
- Assistance from Bob Locander (CDOT)
GUIDELINE FOR ASPHALT PAVEMENT DESIGN IN COLORADO

- Currently in Draft form, under review by CAGE Board
- Modifications and comments from general membership
- Anticipated publish date, April 2010
Why?

- Assists Municipalities in developing and updating their current design standards
- Promotes the best practices that produce a pavement structure appropriate to its intended service
- Developed for consideration by Professional Engineers practicing engineering in Colorado
Why?

- Not to be used as a design manual!
- Local jurisdictional design standard should be followed!
Subgrade Investigation

❖ Time of the Investigation

– Completion of site grading
– Capital Improvement Projects – may not be feasible

❖ Evaluate subgrade at final elevation in cut areas
Subgrade Investigation

❖ Spacing of Borings
  – Streets – 250 to 500 feet, one per street
  – Parking Lots – Judgment of Engineer

❖ Depth of Exploration
  – 5 to 10 feet with minimum 5 to 10 feet below final subgrade elevation in cut areas
  – Suggest minimum 20% to 25% to be 10 feet
Subgrade Investigation

- **Sampling Procedures**
  - Borings drilled by auger procedures
  - Excavation of test pits sometimes appropriate
  - Split Spoon sampler for granular soils
  - California sampler for cohesive soils
  - Drive samples in the upper 1 to 2 feet below final subgrade elevation

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Laboratory Testing

✦ Natural moisture content and dry density
✦ Soil classification
✦ Swell-consolidation
✦ Subgrade Support
  – Hveem R-value
  – California Bearing Ratio (CBR)
  – Remolded Unconfined Compressive Strength
  – Support value based on soil classification
Laboratory Testing

- Water Soluble Sulfates
- Proctors
- Remolded Swell
Subgrade Design Strength

- Asphalt pavements designed using a subgrade resilient modulus
- Requires correlation of R-value, CBR or remolded unconfined compressive strength to resilient modulus
- CDOT has correlation for R-value
- AASHTO has several correlations for CBR
Subgrade Design Strength

- MGPEC has equations for remolded unconfined compressive strength
- Designer should closely consider results when selecting final design resilient modulus
Subgrade Preparation

- Compacted Subgrade
  - Moisture-density treatment of upper 8 to 12 inches
  - AASHTO T-99 and T-180 depending upon soil classification
Subgrade Preparation

- **Swelling Subgrade**
  - Swell mitigation should be addressed when swell is greater than 2% under surcharge pressures of 150 to 200 psf
  - Localized areas of higher swell potential addressed individually
  - CDOT and MGPEC provides additional reference material
Subgrade Preparation

- Swelling Subgrade
  - Generally accepted mitigation techniques
  - Overexcavation and moisture-density treatment
    - Typical depths 2 to 5 feet
    - Addition of moisture to a value near or over optimum
Subgrade Preparation

- **Swelling Subgrade**
  - Generally accepted mitigation techniques
  - **Removal and Replacement**
    - Depth of removal generally 1 to 3 feet
    - Replacement with granular soil
    - Use of edge drains should be considered
Subgrade Preparation

- **Swelling Subgrade**
  - Generally accepted mitigation techniques

- **Chemical Treatment**
  - Performed in upper 8 to 12 inches
  - Used in conjunction with moisture-density treatment
  - Lime, cement, fly ash
Subgrade Preparation

- Soft and Saturated Subgrade
  - Generally accepted mitigation techniques
    - Chemical Treatment
      - Dry with lime, cement, fly ash to provide stable platform
    - Mechanical Treatment
      - Non-reinforced and reinforced techniques
Design Traffic

- Axle loads normalized to damage by 18-kip single axle load (ESAL)
- Recommend site specific traffic studies
Design Traffic

ranges in ESALs based on street classification

- Arterial - 1,460,000 to 1,825,000
- Major Collector – 730,000 to 1,095,000
- Minor Collector – 219,000 to 365,000
- Local – 58,400 to 73,000
- Cul-de-sac – 36,500 to 58,400
Design Traffic

- Ranges in ESALs for parking lots
  - Automobile stalls – 21,900 to 36,500
  - Secondary drives – 36,500 to 58,400
  - Primary drives – 58,400 to 73,000
  - Loading docks – 73,000 to 182,500*

*Anticipated site specific traffic should be evaluated
Pavement Design Equation

- 1993 AASHTO Pavement Design Procedures
- Pavement design equation solved by:
  - DARWin™
  - Nomograph
  - Industry programs/resources
Pavement Design Equation

- **AASHTO Input Parameters**
  - **Initial Serviceability**
    - 4.5 for all street classification
  - **Terminal Serviceability**
    - 2.5 for Arterials and Collectors
    - 2.0 for local, cul-de-sac, parking lots
  - **Standard Deviation**
    - 0.44 regardless of classification
Pavement Design Equation

- AASHTO Input Parameters
  - Reliability
    - 90% to 95% - Arterial and Major Collector
    - 85% to 90% - Minor Collector
    - 80% to 85% - Local
    - 75% to 80% - Cul-de-sac and Parking Lots
Design Thickness

Conversion of Structural Number to layer thickness’

SN = a₁D₁ + a₂D₂m₂ + a₃D₃m₃

where

- a₁, a₂, a₃ = layer coefficients representative of hot mix asphalt, aggregate base, and subbase courses
- D₁, D₂, D₃ = actual thickness (in inches) of hot mix asphalt, aggregate base, and subbase courses
- m₂, m₃ = drainage coefficients for base, and subbase courses
Design Thickness

◆ Layer Coefficients
  - Hot Mix Asphalt          0.40 to 0.44
  - Granular Base Course     0.12 to 0.14
  - Chemically Treated Subgrade
    ◆ Lime, Cement, Fly Ash   0.11 to 0.14
  - Cement Treated Base Course 0.20 to 0.22
  - Bitum. Treated Base Course 0.20 to 0.22
Design Thickness

- **Drainage Coefficients**
  - Range from 0.7 - 0.8 for very poor subgrade to 1.1 - 1.15 for excellent subgrades
  - Generally Accepted by Geotechnical/Pavement Engineers in Colorado to use a drainage coefficient of 1.0 for unbound base and subbase layers
Pavement Section Alternatives

❖ Full-Depth
  – Placed directly on prepared subgrade
  – Thickness generally ranges from 5 to 10 inches
  – Addition of base layer to be considered if over 10 inches is needed
Pavement Section Alternatives

- **Flexible Composite**
  - Asphalt over aggregate base course on prepared subgrade
  - Separation geotextile should be considered on cohesive soils
  - Edge drains should be considered on cohesive soils
Pavement Section Alternatives

- Flexible Composite
  - Base thickness generally ranges from 6 to 12 inches
  - General guidance for ratio of aggregate base thickness to hot mix asphalt thickness
    - 2:1 to 2.5:1
Pavement Section Alternatives

- Chemically Treated
  - Asphalt over chemically treated with lime, cement or fly ash
  - Treated layer part of structural section
  - Requires adequate improved strength (typical min. 160 psi)
  - Range in thickness – 8 to 12 inches
Pavement Section Alternatives

- Mechanically Treated
  - Asphalt over reinforced granular base
  - Reinforcement – multi-axial geogrid placed on stable prepared subgrade
  - Provides for reduction in aggregate base thickness
  - Starting to be recognized, yet to be officially accepted by most agencies
Asphalt Mix Selection

- Superpave Mix Design & Mix Selection
- Three primary components
  - PG Asphalt Binder Selection
  - Gyrator Compaction Level
  - Aggregate Gradation and Physical Properties
Asphalt Mix Selection

◆ PG Asphalt Binder Selection
  - PG 58-34*, minor collectors, locals, parking lots, very low temperature areas and mountainous areas
  - PG 58-28, minor collectors, locals, parking lots
  - PG 64-22, major collectors, arterials, most commonly used binder
Asphalt Mix Selection

- PG Asphalt Binder Selection
  - PG 64-28*, major collectors, arterials, colder temperature areas
  - PG 70-28*, PG 76-28*, major collectors, arterials

*polymer modified binder generally restricted to top lift/wearing surface
Asphalt Mix Selection

- **Gyratory Compaction Level**
  - 50 – Occasional light vehicular and pedestrian traffic, bike paths, playgrounds, tennis courts
  - 75 – Predominate level used, parking lots, locals, collectors, minor arterials
  - 100 heavy high volume arterials and interstates

- **CDOT provides guidance on levels based on ESALs and temperature**
Asphalt Mix Selection

Aggregate Gradation and Lift Thickness

- SX (modified), <1-1/2 inches, preventative maintenance, thin overlays, surface mixes
- SX (1/2”), 1-1/2 to 2-1/2 inches, surface mixes and some intermediate mixes
- S (3/4), 2 to 3 inches, bottom, intermediate and some surface mixes
- SX (modified), <1-1/2 inches, preventative maintenance, thin overlays, surface mixes
Asphalt Mix Selection

- Stone Matrix Asphalt (SMA)
  - Surface layer on streets that experience extreme traffic loadings
  - Gap-graded HMA that maximizes rutting resistance and durability
  - Stable stone-on-stone skeleton held together by a rich mixture of asphalt binder, filler, and stabilizing agents
Recent/New Technologies

- Perpetual Pavements
- AASHTO M-E Design Approach

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