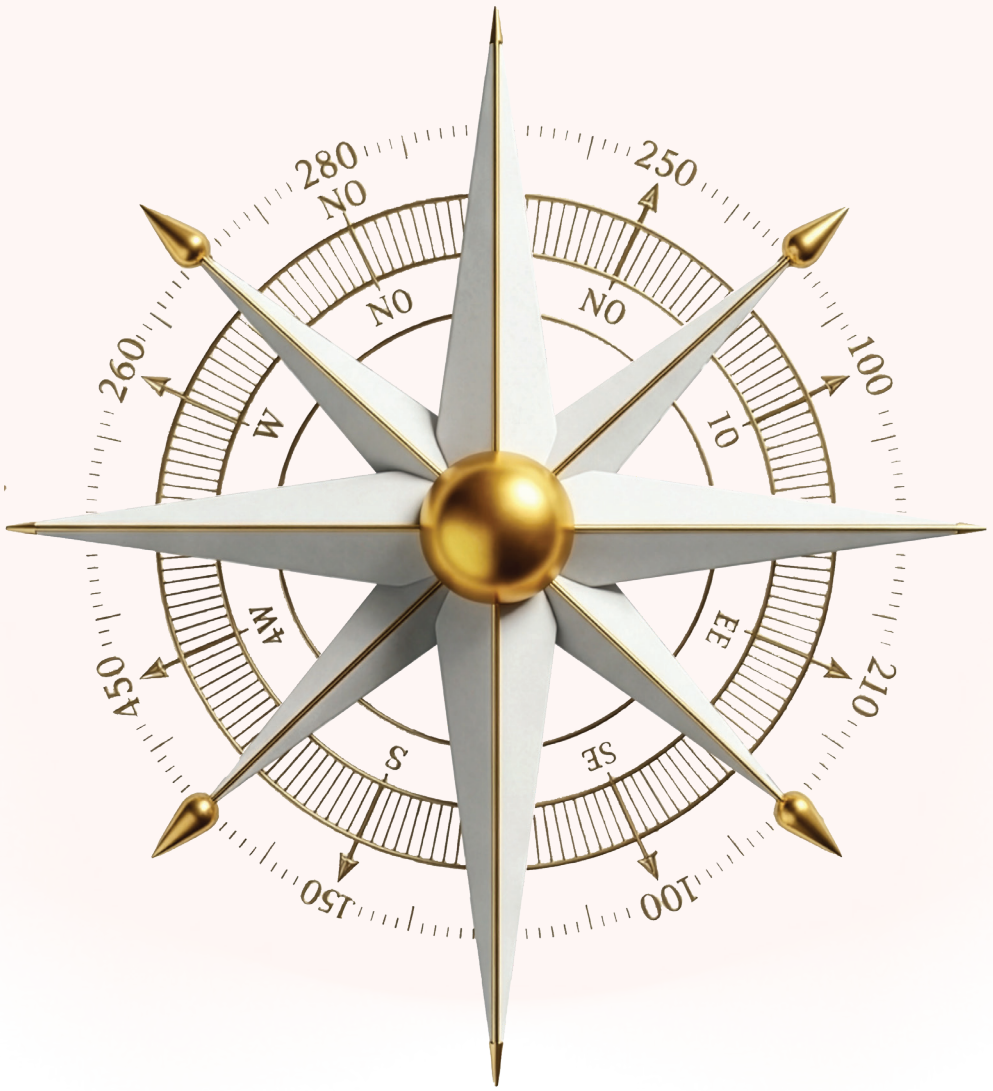
CONCEPT

Highway Geometric Design and Pavement Design: Alignment, Pavement Thickness and Road Drainage



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Introduction:

Road schemes often reach tender with curves that fail sight distance checks, superelevation that ponds water, and pavement layers sized by habit rather than by traffic loading and subgrade strength. This Core Concept two-week course in highway geometric design and pavement design gives road engineers a calculation method for each design stage: design controls, sight distance, horizontal and vertical alignment, cross-sections and junction geometry, then flexible and rigid pavement thickness, asphalt mix design for hot climates and road drainage. Participants finish by producing a Road Segment Design Report.

Course Objectives:

- Set design controls for a road project, including functional class, design speed, design vehicle and terrain, and apply the matching geometric criteria
- Calculate stopping, passing, decision and intersection sight distances and check them against plan and profile
- Design horizontal curves, superelevation runoff and crest and sag vertical curves that satisfy speed and sight distance criteria
- Lay out cross-sections, at-grade intersections, interchange ramps and roadside safety features at design level
- Determine flexible and rigid pavement thickness from traffic loading, subgrade support and material properties using empirical and mechanistic-empirical concepts
- Specify asphalt mixes, granular base and road drainage, including culvert sizing, suited to hot-climate roads

Target Audience:

- Engineers who prepare road alignment, plan and profile drawings for new and widened roads
- Engineers who design pavement structures and specify asphalt and granular layer materials
- Municipal and road authority engineers who check and approve consultant road design submissions
- Contractor design and technical office engineers who prepare design-and-build road packages and value-engineering proposals
- Engineers who design road surface drainage, subsurface drainage and culverts

Course Outline:

Day 1: Design Controls and Geometric Design Criteria

- Functional Road Classification and Access Control Levels
- Design Speed, Operating Speed and Speed Consistency Checks
- Design Vehicle Selection and Swept Path Templates
- Terrain Class, Topographic Survey and Digital Terrain Model Inputs
- Green Book Structure: A Policy on Geometric Design of Highways and Streets and Its Criteria Tables

Day 2: Sight Distance Design and Verification

- Stopping Sight Distance: Perception-Reaction Time and Braking Distance on Grades
- Passing Sight Distance on Two-Lane Rural Roads and No-Passing Zone Layout
- Decision Sight Distance at Lane Drops, Exits and Complex Locations
- Intersection Sight Triangles for Stop and Yield Control
- Horizontal Sightline Offset on Curves and Obstruction Clearance

Day 3: Horizontal Alignment and Superelevation

- Circular Curve Geometry: Radius, Deflection Angle and Stationing
- Minimum Radius from Design Speed, Side Friction Factor and Maximum Superelevation Rate
- Superelevation Distribution Methods and Rate Tables
- Superelevation Runoff, Tangent Runout and Axis of Rotation
- Spiral Transition Curves and Curve Widening for Large Vehicles

Day 4: Vertical Alignment and Cross-Section Elements

- Grade Controls: Maximum Grades, Critical Length of Grade and Climbing Lanes
- Crest Vertical Curve Length from Stopping Sight Distance and K Values
- Sag Vertical Curve Design by Headlight Sight Distance, Comfort and Drainage
- Plan and Profile Coordination in Civil 3D or OpenRoads Designer
- Cross-Section Elements: Lane Width, Shoulders, Medians, Cross Slope and Side Slopes

Day 5: Intersections, Interchanges, Roadside Safety and the Guided Alignment Case

- At-Grade Intersection Geometry: Corner Radii, Channelisation and Auxiliary Turn Lanes
- Interchange Forms and Ramp Geometry: Diamond, Cloverleaf and Directional Ramps
- Speed-Change Lanes: Acceleration and Deceleration Taper Design
- Roadside Design: Clear Zone, Recoverable Slopes and Safety Barrier Warrants
- Guided Case: Plan and Profile Check of a Rural Highway Section

Day 6: Pavement Structure, Traffic Loading and Subgrade Characterisation

- Flexible and Rigid Pavement Structure: Surface, Base, Subbase and Subgrade Roles
- Traffic Loading Analysis: Axle Load Spectra, Load Equivalency Factors and Design ESALs
- AASHTO Soil Classification Groups A-1 to A-7 and Subgrade Rating
- Subgrade Strength Testing: CBR, Resilient Modulus and Plate Load Correlations
- Subgrade Improvement: Lime and Cement Stabilisation and Granular Capping Layers

Day 7: Flexible Pavement Thickness Design

- AASHTO Empirical Method Inputs: Serviceability Loss, Reliability and Standard Deviation
- Structural Number Calculation with Layer and Drainage Coefficients
- Layer Thickness Selection and Minimum Thickness Checks for Asphalt and Granular Base
- Mechanistic-Empirical Concepts: Layered Elastic Analysis, Critical Strains and Transfer Functions
- Fatigue Cracking and Rutting Damage Prediction Under Heavy Axle Traffic

Day 8: Asphalt Materials and Superpave Mix Design for Hot Climates

- Superpave Performance Grade Binder Selection for High Pavement Temperatures
- Aggregate Consensus Properties: Angularity, Flat and Elongated Particles and Sand Equivalent
- Superpave Gyratory Compactor and Volumetric Design: Air Voids, VMA and VFA
- Rut-Resistant Mix Options: Polymer-Modified Binders and Stone Matrix Asphalt
- Granular Base Specification: Gradation Envelopes, Compaction and Moisture Sensitivity Tests

Day 9: Rigid Pavement Design and Road Drainage

- Jointed Plain Concrete Pavement Thickness: Modulus of Subgrade Reaction and Flexural Strength Inputs
- Joint Layout, Dowel Bars, Tie Bars and Load Transfer Design
- Surface Drainage: Rational Method Runoff, Kerb Inlet Spacing and Gutter Flow Spread
- Culvert Hydraulic Sizing: Inlet and Outlet Control and Allowable Headwater
- Subsurface Drainage: Permeable Bases, Edge Drains and Drainage Coefficient Selection

Day 10: Capstone: Road Segment Design Report

- Capstone Brief: Corridor Constraints, Traffic Count and Soil Investigation Pack
- Alignment Package: Horizontal Curves, Superelevation Table and Vertical Profile
- Pavement Structure Options: Flexible Versus Rigid Design Comparison
- Drainage and Culvert Layout for the Design Segment
- Road Segment Design Report Presentation and Peer Design Review

Skills You Will Gain:

- Design Control Selection
- Sight Distance Analysis
- Superelevation Design
- Vertical Curve Design
- Roadside Safety Design
- Traffic Load Estimation
- Asphalt Mix Design
- Culvert Hydraulic Design

Why Attend This Course:

- Leave with a Road Segment Design Report for a realistic corridor, covering alignment, pavement structure and drainage, reviewed by peers
- Cover both halves of road design in one course: week one builds geometric design and week two adds pavement thickness, materials and drainage
- Check consultant and contractor road submissions with worked calculation sheets for curves, vertical profiles, structural number and culvert headwater
- Compare design practice with engineers from municipalities, road authorities, consultancies and contractors working on urban, rural and desert roads

Conclusion:

A road performs only when its geometry and its pavement are designed together. Week one covers highway geometric design: design controls, sight distance, horizontal curves and superelevation, vertical curves, cross-sections, intersections, interchange ramps and roadside safety. Week two adds pavement design: traffic loading and subgrade support, flexible thickness by empirical and mechanistic-empirical concepts, Superpave mixes for hot climates, jointed concrete pavement and drainage with culvert sizing. The capstone brings both weeks into a Road Segment Design Report that participants can use as a checklist for their next scheme.