Appendices

Appendix A: MassHighway District Offices and Jurisdiction

District 1 Highway Director : Ross Dindio
270 Main St.
Lenox, MA 01240
Tel : (413) 784-1768, (413) 637-1750
Fax : (413) 637-0309

Adams
Alford
Ashfield
Becket
Blandford
Buckland
Charlemont
Cheshire
Chester
Chesterfield
Clarksburg
Colrain
Conway
Cummington
Dalton
Egremont
Florida
Goshen
Granville
Great Barrington
Hancock
Hawley
Heath
Hinsdale
Huntington
Lanesborough
Lee
Lenox
Middlefield
Monroe
Monterey
Montgomery
Mount Washington
New Ashford
New Marlborough
North Adams
Otis
Peru
Pittsfield
Plainfield
Richmond
Rowe
Russell
Sandisfield
Savoy
Sheffield
Shelburne
Stockbridge
Tolland
Tyringham
Washington
West Stockbridge
Williamsburg
Williamstown
Windsor
Worthington

District 2 Highway Director : John Hoey, Jr.
811 North King St.
Northampton, MA 01060
Tel : (413) 584-1611
Fax : (413) 584-8194

Agawam
Amherst
Athol
Barre
Belcherton
Bernardston
Brimfield
Chicopee
Deerfield
East Longmeadow
Easthampton
Erving
Gill
Granby
Greenfield
Hadley
Hampden
Hardwick
Hatfield
Holland
Holyoke
Leverett
Leyden
Longmeadow
Ludlow
Monson
Montague
New Braintree
New Salem
Northampton
Northfield
Orange
Palmer
Pelham
Petersham
Phillipston
Royalston
Shutesbury
South Hadley
Southampton
Southwick
Springfield
Sunderland
Templeton
Wales
Ware
Warren
Warwick
Wendell
West Brookfield
West Springfield
Westfield
Westhampton
Whately
Wilbraham
Winchendon

District 3 Highway Director : Thomas Waruzila
403 Belmont St.
Worcester, MA 01604
Tel : (508) 754-7204
Fax : (508) 799-9763

Acton
Ashbumham
Ashby
Ashland
Auburn
Ayer
Bellingham
Berlin
Blackstone
Bolton
Bosborough
Boylston
Brookfield
Charlton
Clinton
Douglas
Dudley
Dunstable
E. Brookfield
Fitchburg
Framingham
Franklin
Gardner
Grafton
Groton
Harvard
Holden
Holliston
Hopedale
Hopkinton
Hubbardston
Hudson
Lancaster
Leicester
Leominster
Littleton
Lunenburg
Marlborough
Maynard
Medfield
Medway
Mendon
Milford
Millbury
Millis
Millville
N. Brookfield
Natick
Northborough
Northbridge
Oakham
Oxford
Paxton
Pepperell
Princeton
Rutland
Sherborn
Shirley
Shrewsbury
Southborough
Southbridge
Spencer
Sterling
Stow
Sturbridge
Sudbury
Sutton
Townsend
Upton
Uxbridge
W. Boylston
Wayland
Webster
Westborough
Westford
Westminster
Worcester

District 4 Highway Director : Stephen O'Donnell
519 Appleton St.
Arlington, MA 02174
Tel : (781) 641-8300
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Amesbury
Andover
Arlington
Bedford
Belmont
Beverly
Billerica
Boston
Boxford
Braintree
Brookline
Burlington
Cambridge
Canton
Carlisle
Chelmsford
Chelsea
Concord
Danvers
Dedham
Dover
Dracut
Essex
Everett
Georgetown
Gloucester
Groveland
Hamilton
Haverhill
Ipswich
Lawrence
Lexington
Lincoln
Lowell
Lynn
Lynnfield
Malden
Manchester
Marblehead
Medford
Melrose
Merrimac
Methuen
Middleton
Milton
N. Andover
N. Reading
Nahant
Needham
Newburyport
Newton
Peabody
Quincy
Randolph
Reading
Revere
Rockport
Rowley
Salem
Salisbury
Saugus
Somerville
Stoneham
Swampscott
Tewksbury
Topsfield
Tyngsborough
W. Nebury
Wakefield
Waltham
Weston
Westwood
Weymouth
Wilmington
Winchester
Winthrop
Woburn

District 5 Highway Director : Bernard McCourt
1000 County St.
Taunton, MA 02780
Tel : (508) 824-6633
Fax : (508) 880-6102

Abington
Acushnet
Attleboro
Aquinnah
Avon
Barnstable
Berkley
Bourne
Brewster
Bridgewater
Brockton
Carver
Chatham
Chilmark
Cohasset
Dartmouth
Dennis
Dighton
Duxbury
E. Bridgewater
Eastham
Easton
Edgartown
Fairhaven
Fall River
Falmouth
Foxborough
Freetown
Gosnold
Halifax
Hanover
Hanson
Harwich
Hingham
Holbrook
Hull
Kingston
Lakeville
Mansfield
Marion
Marshfield
Mashpee
Mattapoisett
Middleboro
N. Attleborough
Nantucket
New Bedford
Norfolk
Norton
Norwell
Norwood
Oak Bluffs
Orleans
Pembroke
Plainville
Plymouth
Plympton
Provincetown
Raynham
Rehoboth
Rochester
Rockland
Sandwich
Scituate
Seekonk
Sharon
Somerset
Stoughton
Swansea
Taunton
Tisbury
Truro
W. Bridgewater
W. Tisbury
Walpole
Wareham
Wellfleet
Westport
Whitman
Wrentham
Yarmouth

Appendix B: MassHighway Design Manual Table 8.2

Appendix C: Guardrail Offset Distance

Post Spacing	Beam Description	Minimum Offset (m)
Single	Single W - Beam	1.25
Single	Single Thrie – Beam	1.10
Double	Single W – Beam	0.95
Double	Double W – Beam	0.85
Double	Single Thrie – Beam	0.90
Double	Double Thrie – Beam	0.80
Quadruple	Double W – Beam	0.70
Quadruple	Single Thrie – Beam	0.75
Quadruple	Double Thrie – Beam	0.70

Note: Measured from the face of the rail to the front of the obstacle.

Source: MassHighway Design Manual 1997 Edition, Table 9.3.

Appendix D: Glossary

AASHTO (American Association of State Highway Transportation Officials): An agency that, among other responsibilities, sets guidelines for road, highway and bridge design.

Batter: A design feature that gives a receding upward slope to the face of a wall. Primarily, batter serves to enhance the gravitational stability of the wall and to provide resilience against misalignment.

Bin Walls: These gravity retaining walls (sometimes referred to as cellular walls) are comprised of interlocking reinforced concrete modules that are stacked on top of one another and then filled with granular materials such as gravel.

Blocked-Out Steel-Backed Timber Guardrail System: This system offers a design that is visually pleasing and can handle collision situations. It functions like a traditional metal post and rail system. The steel backing prevents vehicles from penetrating the barrier and impacts against the rails are carried down the posts into the ground. The steel elements are manufactured from weathering steel allowing them to blend into the landscape more readily. The wooden block between the post and the steel backing plate minimizes the danger of wheels getting caught on the posts.

Box Beam Semi-Rigid Guardrail System: This system consists of 6" by 6" steel tube mounted on steel posts that are set on 6-foot centers. Posts nearest the point of impact break or tear away and the force of impact is distributed to other posts. This system's impact resistance depends on a combination of the tensile strength and the flexing ability of the rails. It is recommended that the top of the rails are 27 inches above the ground to redirect vehicles safely back to the travel lane.

Candlepower: The intensity of light output in all directions regardless of surface aberrations.

Cantilevered Walls: In cross section most cantilevered walls look like Ls or inverted Ts. A base is tied to the vertical portion of the wall with reinforcement rods. The base is backfilled to counteract forward pressure on the vertical portion of the wall. The cantilevered base is reinforced and is designed to prevent uplifting at the heel of the base. Reinforced concrete cantilevered walls sometimes have a batter. They can be faced with stone, brick or simulated veneers.

Cor-Ten Steep (also called "Weathering Steel" and "high-strength steel"): This kind of steel quickly turns brown with surface rust upon exposure to the elements. Corrosion stops once a thin layer of rust coats the metal's surface. This leaves a strong crash withstanding system that is a deep brown color. In some areas, the brown steel blends into the surrounding landscape and is less obtrusive than galvanized steel. Cor-Ten is a trade name for corrosion resistant, high strength, low alloy steel meeting ASTM standard designation A588 with a minimum yield stress of 50,000 pounds per square inch.

Crib Walls: Crib Walls are made of interlocking reinforced concrete headers and stretchers that are stacked like the walls of a log cabin. Once these elements are assembled they are locked together by protruding lugs. Then the wall structure is filled with granular material such as gravel to provide both stability and drainage. Usually these walls are quite large and appropriate where heavy construction equipment can be used to lay the courses.

Cross Sectional Geometry: The cross sectional layout, widths, and superelevation of the elements of the roadway: travel lanes, shoulders, curbs, medians, and so on. Surface slopes and crowns of the travel lanes are necessary to allow sufficient drainage.

Cutoff Fixtures: These fixtures direct light downward in a visually comfortable pattern. Sharp cutoffs use optical design and reflectors to reduce glare by only shining light downward and keeping the spread of light at least 15 degrees below the horizon line.

DPW (Department of Public Works): The old name of the agency Massachusetts Highway Department (MHD). MHD is the state agency responsible for the construction and maintenance of state roads and bridges.

Design Speed: The maximum speed that is considered safe when conditions favor the design features of the roadway.

Earth Tieback Retaining Walls: These walls are counterbalanced not by a large base but by a series of horizontal bars or strips extending out perpendicularly from the vertical surface into the slope. The bars or strips, sometimes called “deadmen” are made of wood, metal, or synthetic material such as geotextiles. Once an earth tieback retaining wall is backfilled, the weight and friction of the fill against the horizontal members anchors the structure.

FHWA (Federal Highway Administration): The federal agency that oversees federal road, highway, and bridge programs and policy.

Flexible Construction: This refers to retaining wall structures that can tolerate some differential movement without losing structural stability. These structures include bin walls, dry stone walls, gabion walls, crib walls and other retaining wall types that are built on permeable, leveling beds and sometimes footings rather than rigid foundations and structures.

Footcandle: Quantitative unit that measures the amount of light at a single point in space. One footcandle is equal to one lumen uniformly distributed over one square foot of area.

Functional Classification: Streets and highways are grouped into functional classifications according to the level of transportation service they are expected to provide. The functional classification hierarchy is composed of principal arterials, minor arterials, collectors, and local roads and streets. Arterials provide the greatest degree of movement from place to place. At the other end of the hierarchy, local roads and streets provide access to land where people live and work. These classifications are subdivided further: in urban areas there is greater distinction among types of arterials and in rural areas there is greater distinction among types of collectors.

Gabion Walls: These walls are made by stacking and tying wire cages filled with trap rock on top of one another. They can have a continuous batter or be stepped back with each successively higher course. This is a good application where the retaining wall needs to allow water to pass through it, as in the case of riverbank stabilization. As relatively flexible structures, they are useful in situations where the soils are unstable.

Gravity Walls: These walls are stabilized by their mass. They are built out of dense, heavy materials such as concrete and stone masonry, usually reinforced. The base width to height ratio of gravity walls usually ranges between 0.40 and 0.45. Some gravity walls do not use mortar, relying solely on their weight to stay in place.

Green Walls: These walls are composed of interconnected precast concrete units. Each unit has an open element that, filled with soil, serves as a planter for vegetation. These units are stacked in staggered courses like concrete blocks but they are shaped so that they can follow curves, giving the wall a more natural flow and allowing it to follow irregular topographic contours. The surfaces may be fabricated and colored to simulate natural stone. Live gabion walls, vegetated crib walls, and vegetated rock walls are other variation of the green wall concept.

High-Angle Lighting: High-angle lighting illuminates the area above the luminaire as well as that below.

High-Mast Lights: These are the taller parking lot and roadway lights. They are used mostly on highways, and large recreational and parking areas and use the same kinds of lamps on much higher stanchions, ranging from 60 to 100 feet. More and more designs are being employed for taller outdoor lights that use reflectors and cutoffs to reduce light pollution and glare.

Highway Guards: Another name for guardrails, or roadside barriers, in Massachusetts.

Intermediate-Height Landscape Lights: These lights usually stand 10-15 feet high and are intended to light pedestrian ways. As with low-level landscape lights they can be fitted with a variety of lamp types: incandescent, mercury vapor, metal halide, or high-pressure sodium.

Lamp: The part of a light that emits light energy is what people commonly think of as a bulb. In outdoor lighting this is called a *lamp*. The most commonly used lamps for outdoor lighting are incandescent, fluorescent, mercury vapor (deluxe white), metal halide, high-pressure sodium (deluxe color), and low-pressure sodium.

Live Fascines: These are bundles of live cut branches. All of their growing tips are oriented in one direction. Then they are placed in trenches and partially covered with a layer of soil. The soil and branches are in contact allowing roots to form. Stems are exposed to sunlight allowing leaves to develop.

Low-Level Landscape Lights: Low-level landscape lights are generally less than 10 feet high and come in many designs to light walkways, highlight landscaping and architecture. They can use most lamp types (incandescent, fluorescent, mercury vapor, or high-pressure sodium) as long as the wattage and intensity is not too high. The amount of light they provide is limited and they are generally below eye level and do not cause glare problems.

Lumen: A unit of measurement that describes the amount of energy coming from a light, regardless of the uniformity of its distribution.

Lux: The International Standard measurement of illumination incident at a single point. Lux is equal to a single lumen evenly distributed over the area of a square meter.

MHD (Massachusetts Highway Department): MHD is the state agency that carries out the state's programs for construction and reconstruction of certain state and local roads and bridges, and administers other local aid programs under the direction of the Governor and the State Legislature, with the use of both State and Federal funds.

Parking Lot and Roadway Lights: The main purpose of these lights is to illuminate large areas of roadway, parking lots, recreational, and industrial space. Typically, heights range from 20 to 50 feet. Ornamental fixtures are available, but the emphasis is generally on low-maintenance utility. Lamp types include mercury vapor, metal halide, and high pressure sodium.

Reconstruction: Major roadway rehabilitation often requiring major excavation and widening of the existing roadway.

Recovery Zone: This is the area beyond the travel lane that needs to be kept clear of potential fixed object hazards.

Repaving: Repaving usually consists of a "leveling" course that corrects deficiencies in the cross sectional geometry of the road over which an "overlay" course of new or recycled bituminous asphalt is applies. Repaving is also used to prolong the useful life of a roadway to forestall more costly rehabilitation and reconstruction projects where the underlying structure and drainage is adequate.

Retaining Walls: Walls that contain the earth behind them and serve to moderate terrain. When roadway construction is necessary over rugged terrain with steep slopes a series of retaining walls can establish relatively flat horizontal planes. Some road projects lack available land beside the travelway, requiring construction right along the toe of a slope. In these cases appropriate grading may not be possible and retaining walls become necessary to stabilize the solids along the roadway allowing for safe construction and acceptable slope conditions for adjacent land uses. Where soils are unstable, slopes are quite steep, or heavy runoff is present, retaining walls are often used to stem erosion.

Rigid Construction: This pertains to retaining structures that are intended to remain absolutely stationary. In some cases they are the preferred choice because they match adjoining structures or buildings. Rigid construction includes reinforced concrete and masonry walls held in place by gravity or reinforced cantilevers. To ensure stability, they are built on solid foundations.

Roadside Barriers: Components in road and bridge project designs when a hazard is perceived alongside the roadway. There are three general types of roadside barriers: flexible, semi-rigid, and rigid. Hazards include fixed objects such as non-breakaway light and sign posts, bridge piers and abutments, retaining walls and culverts, trees with diameters of more than 6 inches, rough rock cuts, boulders, embankments, streams, and

permanent bodies of water. Roadside barriers are also employed to separate roadways from pedestrian and bicycle paths, steep grades, to separate opposing traffic lanes, and to define medians. Roadside barriers are set in the roadway's *recovery zone*, the area beyond the travel lane that needs to be kept clear of potential fixed-object hazards.

Running Speed: The speed that vehicles actually travel on a given road section.

Shoulders: Areas beside the travel lane on some roadways intended to buffer and strengthen the edge of the pavement of the travel lane and to facilitate drainage. They also allow drivers to stop in emergencies and avert accidents. There are three shoulder types: *paved shoulders* consist of bituminous or concrete materials, *stabilized shoulders* consist of bituminous material mixed with gravel to provide a compacted and relatively smooth surface, and *unstabilized shoulders* consist of slag, gravel, crushed stone, soil or grass, generally free of trees and other roadside obstacles.

Soil Bioengineering: This means of slope stabilization combines mechanical, biological, and ecological features to stabilize upland slopes and to control erosion. Synthetic or natural materials are used to form a substrate that permits slope stabilization while allowing the planting of groundcover, shrubs, and trees. To form the substrate, the slope is sometimes covered with good sized stones. Then a skin is formed over this surface that combines crushed stone, porous soils, and when necessary geotextiles. Some soil bioengineering techniques do not incorporate synthetic materials at all. Instead they rely on the *living approach*, which uses live plant materials and soil alone to stabilize the slope.

Slope: Slope is a feature of the terrain that is of great importance in road design and landuse. Roads must be graded to the appropriate slope to ensure proper drainage, safe passage, and adequate sighting distances. Although a slope of 2% is hardly evident to the human eye in an open landscape, a slope of 2% from the central crown of a road to its edges is necessary to allow proper drainage of surface precipitation. On unpaved roads a crown of at least 3% is used for the same reason. Slopes are expressed in three ways: a percentage, a proportional ratio, or a degree. Percentage slope is expressed as *rise/run*. If the slope rises 4 feet over a distance of 100 feet it is a 4% slope. Proportion of slope is the ratio of the horizontal distance to the vertical rise, for example
2:1. This means of measurement is usually applied when slopes meet or exceed a ratio of 4:1. Finally, slope is expressed in degrees in the case of large-scale earth moving projects.

Steel Beam Highway Guard-Type SS: Semi-rigid guardrail systems, generally of galvanized steel, used in Massachusetts.

Steel Thrie Beam Highway Guard-Type SS: Semi-rigid guardrail systems, generally of galvanized steel, used in Massachusetts. This system has larger dimensions than the *Steel Beam Highway Guard-Type SS* and is seen mostly where perceived hazards are great.

TIP (Transportation Improvement Program): The TIP is a prioritized, multi-year program of transportation improvement projects in a specific region.

Three-Strand Cable Systems: These flexible barrier systems use posts that are driven into the ground along the roadside and have three cables bolted to them at fixed vertical intervals. This system is designed to wrap around the impacting vehicle and redirect it with minimum force against the vehicle and its occupants. The vehicle's force makes the cables stretch and the posts bend or break. As this occurs the vehicle's kinetic energy is dissipated. Because this system requires elasticity to deflect impact, adequate clear space from potential hazards beyond the guardrail is essential.

Tripping Force: Tripping force occurs when an errant vehicle slides with lateral motion, often with its wheels dug into soft soils or granular materials. If the vehicle reaches critical sliding velocity and hits a low obstacle, such as a curb or slack cable, it is likely to roll over. This is especially true for sport utility vehicles that have a high center of gravity.

Weak Post Roadside Barrier Systems: Designed to bend or break away, the weak post systems are more forgiving to the colliding vehicle and its passengers than strong post systems. However, they require more deflection space, such as a grass shoulder free of obstacles, beyond the barrier than strong post systems.