M A S S

INTERCHANGE

VOLUME 5 NUMBER 3 MARCH 1991

PIPE CULVERTS, DESIGN AND INSTALLATION GUIDELINES

• **PURPOSE**

Culverts are used to provide continuity of flow, that is, to carry water from one side of the roadway to the other, to equalize ponds and marshes on both sides of a road, and to allow animals to pass beneath a road.[1]

• **MATERIAL TYPES**

Pipe culverts are manufactured from various materials. The most common are concrete and reinforced concrete (classified as rigid), and corrugated metal and plastic (classified as flexible).

• **SHAPES**

A variety of shapes are available. Choice depends on characteristics of use and level of performance required. The most common shapes include circular corrugated metal pipes, corrugated metal arches with open floors, corrugated metal pipe arches, corrugated metal ellipses, circular concrete pipes, concrete arches with open floors, and concrete boxes.

• **COMPARISON OF PIPE CULVERTS**

The following are characteristics of concrete and steel culverts.

Concrete pipe culverts

Concrete pipe culverts have good hydraulic characteristics. Pipe roughness is minimal, and this smoothness allows more water to flow through for a given size. Resistance to corrosion from acids common in marshy soils is very high. However, concrete pipe cracks and spalls with age and steel reinforcement is attacked by salts.

Metal/steel pipe culverts

Corrugated pipes have relatively high roughness compared to concrete. Flow through a given size of corrugated metal pipe culvert is less than that for the same size concrete pipe. Corrosion to the pipe from acids in marshy soils and road salts poses a problem as the pipe ages. When installing steel culverts, care should be taken to avoid scratches on the outer coating which accelerate the corrosive process.

Plastic (PVL) pipe culverts

Plastic pipes have relatively high resistance to salt attack in marshy soils. Hydraulic efficiency can be high with minimum pipe roughness. However, structural problems could arise if the protective soil cover above the pipe is inadequate to dissipate the traffic loads imposed.

• **COMMON CULVERT PROBLEMS**

The most common problems that may warrant culvert replacement or improvement include the following: inadequate pipe capacity characterized by frequent flooding and overtopping of the road; structural failure due to excessive soil loading; washout due to water overtopping the road; end scouring from poor end treatment; improper jointing resulting in water piping along the outside of the pipe; erosion due to excessive water transport of sand and gravel; corrosion from acid or salt laden soils and water; improper end walls resulting in embankment failures; poor installation and/or bedding condition resulting in settling, joint separation or structural failure of the pipe; and undercutting and scouring of the roadbed.[1]

• **FACTORS INFLUENCING CULVERT PERFORMANCE**

Culvert performance becomes important in situations of high flow such as flooding, snow melt and rain storms, and should be critically assessed before installation.

An increase in headwater depth, total culvert fall, and/or cross sectional area of the culvert increases the discharge rate. The culvert barrel shape also influences

performance. For the same cross sectional area, arch pipes discharge more flow than circular pipes since the perimeter is greater for the arch pipe.[2] The designer should check the entire roadway elevation within the vicinity of a culvert site and make sure the allowable headwater depth does not exceed low points on the roadway.

Length and alignment also affect culvert performance. The longer the culvert length, the more roughness is encountered resulting in a decrease in the discharge rate. Improper culvert alignment can lead to a decrease in the performance due to changes in flow direction and hence decrease in the discharge rate.

• DESIGN CONSIDERATION

The design process is governed by the expected design storm, the proposed or existing roadway width and elevation, elevations of surroundings, the natural stream characteristics, in situ soil characteristics, and construction and maintenance costs.

Selection of culvert type

Selection of a culvert type depends primarily on material and installation cost, site characteristics, and likelihood of corrosion, and salt attack. For sites where acid and salt attacks are expected, plastic and concrete culverts are recommended. However, the time and labor requirement for concrete is quite high compared to steel and plastic pipe culverts. In addition, the weight of concrete sets a minimum equipment requirement.

On the other hand, corrugated metal and plastic pipe culverts may be easy to install but might not be suitable in terms of cost and site conditions.

Local preference, proximity to manufacturing site, and equipment involvement also influence material type selection.

Culvert sizing

Where a culvert has to be replaced, usually a new culvert having the same size and dimensions as the previous is installed. However, examine the history during periods of high flow, snow melt, and heavy rainfall to determine if there have been instances of inadequate pipe capacity. Study upstream and downstream conditions, including new or proposed developments, to determine whether additional flows can be expected. Review maintenance records and flooding history and assess existing culvert capacity for adequacy. Site observations, such as any unusual deposits of grass and brush on fences in the vicinity, and soil erosion and deposition on surroundings away from the normal stream channel, are indications of flooding and inadequacy of culvert capacity. Consult residents and people familiar with the location.[1]

• INSTALLATION

Alignment

The upstream and downstream watercourse greatly determines culvert alignment. Culverts, at times have to be skewed to the roadway and placed to ensure a straight flow in and out of the pipe. When possible install culverts in line with the upstream/downstream watercourse. Perpendicularity to the roadway should not always control the alignment. This objective is very important as it greatly reduces the chances of turbulence created by changes in flow direction resulting in undercutting and scouring away of stream banks and embankment (see Figure 1).

Grade

Where the natural stream channel slope cannot be maintained, great care should be taken in deciding on the culvert slope. Typically, the culvert should be self-cleansing. For low headwater depths, the flow line grade of the pipe culvert should be 2% or more.

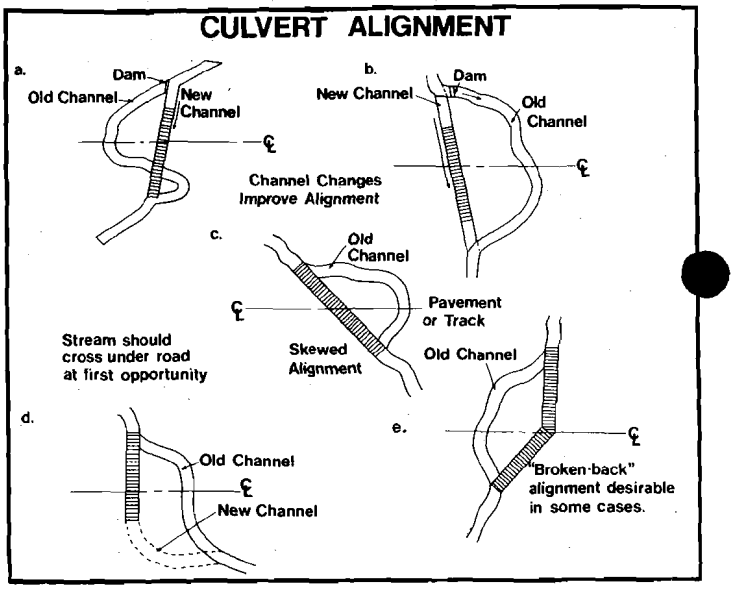

Figure 1.
Suggested methods of obtaining correct culvert alignment (Source: Reference 3).

Bed Preparation

Culvert bed preparation is extremely important in the design and installation phase. The type of bedding is determined by (1) the culvert material type, that is whether rigid (concrete) or flexible (corrugated metal/plastic), and (2) the load carrying mechanism.

For concrete culverts (classified as rigid), the backfill and traffic loads on top are carried entirely by the culvert itself. As a result, a well-built base that will not exhibit any significant flexing is required. Any flexing of the concrete culvert can cause cracking a

subsequent failure. Therefore, the stronger the bedding the larger the load that can be placed on the culvert. Concrete culverts can be installed on piling. The best type of bedding for a concrete culvert is a bedding made of concrete. This type can permit up to 33 feet of fill of density 130 pounds per cubic feet to be placed on top. The least strongest bedding is just the flat trench bottom without any bedding preparation. This type can carry less than 7 feet of the type of fill mentioned above (see Figure 2).

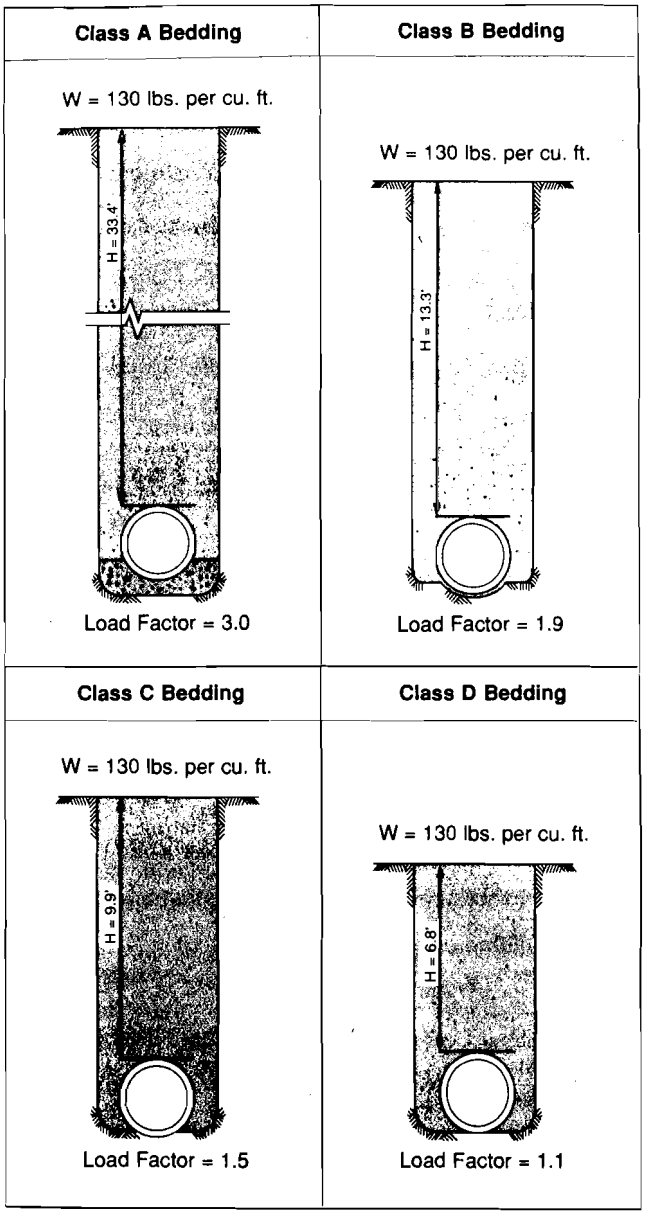

Figure 2.
Bedding is extremely important. The Class A bedding, a concrete bed, permits culvert pipe to withstand three times the load of Class D bedding, unprepared native soil in the trench bottom. (Source: Reference 2)

Culverts made from corrugated metal and plastic have the ability to flex and shed some of the loads imposed on them. Their load carrying mechanism depends on their flexibility. Therefore, they should never be placed on a rigid bedding such as piling or concrete. A typical bedding should be of compacted granular material of thickness 4 inches to 6 inches. Adequate compaction is necessary to keep the degree of flexibility within acceptable limits, and to reduce deformation through excessive bending.

Laying and Jointing
To prevent joint and subgrade failures, and subsequent piping of water along the culvert, the specified banding or jointing instructions should be followed. As much as possible, follow procedures specified by manufacturers or suppliers.

Backfilling and Compaction
Proper backfilling of any culvert increases the culvert's capacity to carry loads. The backfill must be properly placed in thin layers of 6 to 8 inches, and each layer carefully compacted.

A hand-operated vibratory tamper or compactor is recommended for this operation. Where compaction requirement for the backfilling is not specified, the degree of compaction should not be less than the required density specified for the roadway.

The culvert crew should make sure the soil under the culvert haunches is properly placed and compacted. In addition, any layer of soil placed should be adequately compacted before the addition of another layer. Proper backfilling and compaction control will greatly increase the culvert strength and prevent washouts and settling (see Figure 3).

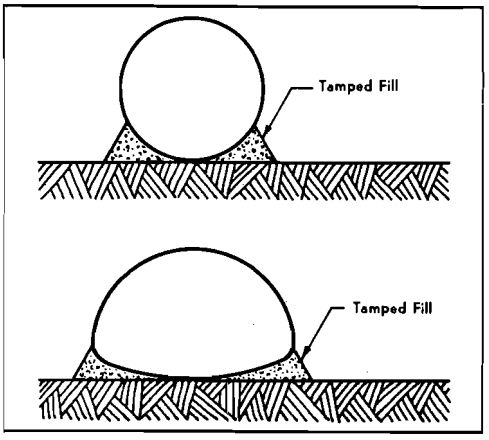

Figure 3.
Methods of attaining proper compaction under haunches of Pipe culverts. (Source: Reference 3).

Continued on page 7

VIDEOTAPES

PA-137
"Subsurface Utility Engineering"

Subsurface utility engineering is an emerging technology. Its purpose is to provide accurate information on the horizontal and vertical location of underground utility facilities during the early development of highway projects. This information can be used in the location and design of highway improvement projects to minimize conflicts with underground utilities.

Benefits of subsurface utility engineering include:

Fewer conflicts with utilities.

Reduced delays in construction schedules due to unexpected utility conflicts.

Elimination of added construction costs due to unforseen utility adjustments.

Fewer contractor claims based on utility delays.

Elimination of safety hazards and service disruptions due to utility lines being unexpectedly severed.

Lower bid prices reflecting the above benefits.

The use of subsurface utility engineering should be considered on any highway project that is likely to have a significant impact on underground utility facilities. The cost of this service on a federal aid project is eligible for federal participation.

(12:43 min.)

PA-138
"Technical Advancements for Maintenance Workers"

The video describes the development of new materials, equipment, and procedures to help maintenance workers operate more efficiently and safely, and includes a number of technical advancements forthcoming from SHRP Highway Operations studies.

The objective of the video is to generate continued support for SHRP Highway Operations studies and to present an overview of products, procedures, and systems being developed from these studies.

(11:45 min.)

ST-135 "Fit for the Road"

The Baystate Roads Program recently received a copy of "Fit for the Road" which was made by the Federal Highway Administration. The intent of the video is to inform examining physicians of the physical and emotional demands placed on commercial motor vehicle drivers and the Federal Highway Administration's medical criteria.

(20 min.)

MO-180 "Idea Store Edition #4"

The "Idea Store Edition #4" is here. It is a ten-minute tape from Penn DOT and has segments on:

a) A grate design for fabricating open grating at driveway crossings.

b) How to elminiate snow buildup around the drive wheels of trucks during snow plowing operations. Snow buildup could put the truck over weight limits. (Snow buildup could weigh a ton.)

c) A cross conveyor to backfill side ditches after a repaving or overlay operation. The conveyor attaches to the dump truck and is powered by the truck's hydraulic system.

d) Minimized aggregate loss during blading operations on gravel roads.

e) Reuse of discarded tires for shoulder reinforcement and side slope protection.

f) The design of a portable sign display for use in emergency road closures.

(10 min.)

MO-181 "Traffic Barriers"

Defines roadside, median, and bridge barrier uses and definitions. It covers the different systems of barriers, when installation is appropriate and how to install them. Discussions include end treatments, transitions and standard sections. It covers the effects of blocks on keeping cars away from posts. Also covered is inspection maintenance and repair of each type of barrier.

(46:27 min.)

CALENDAR OF EVENTS

MASSACHUSETTS HIGHWAY ASSOCIATION
Contact: Mr. Gerald L. Daigle
Secretary, MHA
(508) 966-0203

Thursday, April 4
Executive Committee
Marlboro, MA
4 p.m.

Thursday, May 9
Spring Meeting
Wachusett C.C.

NEW ENGLAND CHAPTER OF THE AMERICAN PUBLIC WORKS ASSN.
Contact: Mr. S. Robert Pryzby
Secretary/Treasurer.
New England Chapter APWA
34 Hawthorne Mead Drive
Glastonbury, CT 06033

Wednesday, April 17
Spring Meeting
Hanover, NH

Sunday, May 19 - Saturday, May 25
Nat'l Public Works Week and Luncheon
Boston, MA

Wednesday, June 19 - Friday, June 21
Summer Meeting
Chatham, MA

UNIVERSITY OF TENNESSEE TRANSPORTATION CENTER
Contact:
University of Tennessee
Knoxville, TN
(615) 974-5255

Tuesday , May 28 - Thursday, May 30
Use of Native Plants in Roadside Beautification Conference

PUBLICATIONS

NEW LISTINGS

"Guide to Earthwork Construction" (TRB/NRC). This publication has been prepared to provide construction engineers and technicians with information on all aspects of earthwork construction. It contains considerable background on the design concepts that are necessary for good earthwork construction. The chapters comprise of: Introduction; History of Embankment Construction; Compaction Concepts; Earthwork Construction; Drainage; Embankment Foundations; Earthwork for Retaining Structures and Abutments; Environmental Considerations; Special Soil Deposits and Embankment Materials; Instrumentation for Embankments - 10 pp.

"A Guide to Wetland Functional Design" (FHWA-IP-90-010). This guidebook was developed as a conceptual guide to replacing wetland functions identified using the Wetland Evaluation Technique (WET, Report No. FHWA-IP-88-029). The functions modified slightly from those in WET include: Nutrient Removal/ Transformation, Sediment/Toxicant Retention, Sediment Stabilization, Floodflow Alteration, Groundwater Recharge, Production Export, Aquatic Diversity, and Wetland Dependent Bird Habitat Diversity. The guidebook offers guidelines for developing both site selection and site design features, and includes a discussion of designing for multiple functions. The information presented in the guidebook is intended as a starting point in wetland functional replacement mitigation. - 230 pp.

"Pavement Management at the Local Government Level" (FHWA-TS-90-042). This report describes a survey and evaluation of the experiences of thirteen agencies which have initiated pavement management activities. Results of the study are presented together with a discussion of factors to be considered in developing a pavement management system (PMS) at the local government level. The report also presents a summary of the PMS implementation expenses for six local government agencies. - 52 pp.

"A User's Guide to Positive Guidance (3rd Edition)" (FHWA-SA-90-017). This publication presents an updated and streamlined version of the Positive Guidance procedure in three parts. Part I provides background information, describes the Positive Guidance concept, and discusses basic concepts underlying the procedure. Part II provides an overview of the Positive Guidance Procedure and describes the office review, improvement development phase, and evaluation. Part III details the revised Positive Guidance diagnostic procedure. In this 3rd edition, the procedure has been augmented by eight checklists to aid in the problem diagnosis process: A--Site Definition; B--Problem Description; C--Hazard Identification; D--Hazard Visibility Assessment; E--Expectancy Violation Determination; G--Information Needs Assessment; and H--Current Information Systems Analysis. - 95 pp.

"Work Zone Traffic Control Information Catalog" (FHWA-TS-90-026) is a publication developed as a ready resource of currently available technology transfer products dealing with the subject of work zone traffic control on streets and highways open for public travel. The list of products include: publications; manuals; guides; training courses; video and slide tape presentations; implementation packages; technology sharing reports; and selected research reports and papers. This publication will be of interest to traffic engineers and work zone managers of state and local highway agencies as well as contractors, utility companies, and others performing construction and maintenance. - 40 pp.

"Effect of Baghouse Fines on Mixture Design Properties" (4/82)
Use of a baghouse collector at a hot mix asphalt facility creates a source of mineral fillers. For economic and environmental reasons, it is desirable to add this baghouse dust to the asphalt mix when appropriate mix design considerations are made. This report presents the results of a study on the effect of baghouse fines on mixture design properties. - 24 pp.

"Guidelines on the Use of Baghouse Fines" (11/87) The disposal of baghouse dust has become a problem for some HMA producers. In recent years, with the introduction of environmental regulations and the adoption of dust collection systems, baghouse fines have been successfully added to asphalt mixtures. This publication describes how to ensure successful, cost-effective use of baghouse fines or other fillers in HMA paving mixes. - 33 pp.

"Making the Most of Temperature Viscosity Characteristics" (2/88)
One of the more difficult problems facing the hot mix asphalt contractor is dealing with the temperature susceptibility of asphalt cements during HMA mixing, storage, and paving operations. This publication gives guidelines on how to use available data on asphalt cement properties in selecting the best temperatures for mixing, compacting, and spraying. - 34 pp.

"Current Industry Practices and Procedures for Determining Asphalt Cement Content in Hot Mix Asphalt" (3/90) The use of chlorinated solvents to determine AC content of HMA samples has come under attack for alleged health and environmental reasons. Also, the test method itself has come under question. This report examines current available methods, advantages & disadvantages, including alternative methods. - 32 pp.

"Using Additives and Modifiers in Hot Mix Asphalt: Part A "(12/88)
An overwhelming number of materials are now being marketed as asphalt additives, modifiers or aids for improving asphalt binders and mixtures. However, a careful review of the constituent materials, their properties and applications, indicates these materials can be grouped or classified for easier understanding, and this publication provides a simplified overview of modifier/ additive types, applications, etc. -12 pp

"A Guide to Thickness Equivalencies for the Design of Asphalt Pavements" (12/84) Guide for translating asphalt surfacing and untreated base into all hot mix asphalt designs, and preparing pavement designs with various types of base courses for making comparisons with total asphalt designs. - 6 pp.

"Development of Marshall Procedures for Designing Asphalt Paving Mixtures" (11/82)
Understanding what is involved in the design of a Hot Mix Asphalt paving mixture and how the various materials are selected, how they act and react with each other, and how the pavement performs is all of vital importance. This publication covers all this, as well as a discussion of how the Marshall procedures for testing mix designs were developed and are used. A basic handbook every Hot Mix firm should have in its library. - 24 pp.

"Design and Performance Study of a Heavy-Duty, Large Stone Hot Mix Asphalt Under Concentrated Punching Shear Conditions" (11/88) This publication describes a laboratory and field study to design a Hot Mix Asphalt (HMA) that could withstand the punching and shearing conditions found in a railroad yard trailer loading and unloading facility. The trials, conducted at a Burlington Northern Railroad yard in St. Paul, Minnesota, in July 1983, were administered with the main objective of designing a mix that could tolerate the high punching shear effect of the steel dolly wheels of a loaded trailer, plus the high gross loads of front-end loaders that load and unload trailers from the rail flat cars. - 15 pp.

"Blistering in Asphalt Pavements: Causes and Cures" (1/87) Describes the mechanisms that can lead to blistering of asphalt pavements, including moisture vapor pressure, soluble salts, uncured steel slags, and microbial action. Also discussed are the effects of factors such as mix characteristics, aggregate properties, drainage, temperature, and construction procedures. Finally, procedures to minimize blistering in asphalt pavements are proposed and suggestions are made on how the probable cause can be determined and what remedial action should be taken - 20 pp.

"Tender Mixes: Probably Causes, Possible Remedies" (rev. 12/88) Although not a frequent problem, tender mixes can cause problems not only to the customer, but also to the contractor who may incur construction delays and/or remedial treatment. Here is an overview of tender mixes, their causes, and potential solutions - 12 pp.

"Hot Mix Asphalt Segregation: Causes and Cures" (8/86) Segregation problems in Hot Mix Asphalt mixtures are the responsibility of all who design, produce, and construct HMA pavements, and those problems can often be avoided if their causes are realized. This publication looks at each process of HMA facility and paving operations that may cause segregation, analyzing the probable cause and possible cure. Included is a diagnostic chart for spotting and solving such problems. - 20 pp.

"Structural Evaluation of Cracked and Seated PCC Pavements for Overlaying with Hot Mix Asphalt" (9/87) Many agencies have shown an interest in cracking and seating or are currently using it as a rehabilitation alternative for distressed PCC pavements. This publication contains the results of a study which determined structural strengths so that overlay thicknesses could be calculated for cracked and seated PCC layers. - 21 pp.

"Constructing Quality Hot Mix Asphalt Pavements - A Trouble-Shooting Guide" (2/87) Often, when constructing Hot Mix Asphalt pavements, a problem arises for which the solution is not readily available and which is thus overlooked at the expense of quality: no longer. This handy guide fits into your coat pocket or glove compartment and will help you identify possible solutions to a number of potential problems that may occur during paving operations. The easy-to-read format makes problem solving simple and quick. - 36 pp.

"Handling and Processing of Reclaimed Asphalt Pavement (RAP)" (rev. 5/88) Reclaimed pavement materials are worth a great deal of money and, as the prices of raw materials increase, are becoming even more valuable. This publication covers the techniques of proper and economical handling of RAP, including safe stockpiling and storage. - 6 pp.

"Asphalt Cement Content Diagnostic Approach for Hot Mix Asphalt Facilities" (4/86) Various problems at the mixing facility can cause the asphalt cement content of Hot Mix Asphalt mixtures to vary from specifications, resulting in poor pavement performance and/or penalties. A diagnostic chart determines where a problem exists and how to remedy it. - 6 pp.

"Good Housekeeping--Your Responsibility" (11/72) The importance of good housekeeping at Hot Mix Asphalt facilities is stressed. Discusses particulates, water quality, fumes, odors and vapors, noise site appearance and buildings, with suggestions for good housekeeping techniques of each. - 24 pp.

"Quality Control for Hot Mix Asphalt Manufacturing Facilities and Paving Operations" (10/86)
A comprehensive guide to setting up a quality assurance program for Hot Mix Asphalt operations. Includes chapters on developing a quality control organization, field and facility operations, sampling and evaluation procedures, personnel requirements, and laboratory requirements plus much more. - 64 pp.

"Effect of Silicones in Hot Mix Asphalt Pavements" (rev. 12/86)
How the addition of silicones affects hot mix laydown. - 4 pp.

"Safe Paving with Sulfur" (12/81)
A guide to the safe handling of sulfur in asphalt mixes. Covers types of sulfur mixes, storage and handling, mixing, placing, environmental and safety aspects. - 6 pp.

"Placing and Compacting Thick Lifts of Hot Mix Asphalt Pavements" (rev. 3/86)
Study of compacting up to 18" of Hot Mix Asphalt lifts. - 16 pp.

"Paver Operations for Quality" (rev. 10/88) Guide for the acquisition of pavers and training of paver operators. Includes operator responsibilities and a yearly, weekly and daily maintenance checklist. - 8 pp.

"Pavement Smoothness" (5/75)
Some aspects of pavement roughness can be controlled during the paving operation by closer attention to underlying causes. This study discusses factors to pay attention to and provides data taken from a systems analysis study of paving operations, plus a handy chart for mating paver speed to mix delivery schedule. - 8 pp."

"Roller Operations for Quality"
(rev. 10/88) Guide for the acquisition of rollers and the training of roller operators. Includes operator responsibilities on the job and a yearly, weekly and daily maintenance checklist. - 4 pp.

"Improving Performance of Longitudinal Construction Joints in Hot Mix Asphalt Pavements" (7/87)
This publication provides a state-of-the-art review of the construction practices for longitudinal joints in HMA pavements. Procedures considered include echelon paving for hot joints, paver and compaction operations for semi-hot and cold joints, re-heating the joint, cutting back the cold side of the joint, and special joint forming techniques. - 10 pp.

continued on page 8

READER'S COMMENTS

March 8, 1991

In the December 1990 issue of Mass Interchange, you presented on page 6 two photographs of devices placed in the roadway advising motorists to stop for pedestrians in crosswalks. Your caption noted the possible liability problem of one of the pictured devices, and indicated that the other (a sign mounted on a plastic barrel) is desirable. Although we share the concern for the safety of pedestrians in the roadway, we do not endorse the use of the plastic barrel device, since we are also concerned with the potential danger that it constitutes. A richocheting plastic barrel could injure a pedestrian which the barrel is intended to protect. In addition, the sign on the impacted drum could become a missile and cause personal injury. Beyond that, the barrel constitutes an obstacle in the roadway that draws attention to itself rather than the condition it is intended to address.

The Federal Highway Administration's Manual on Uniform Traffic Control Devices (MUTCD) does not specifically address the issue of barrels in this application, presumably because it was never an issue. However, under "Traffic Control for School Areas," Section 7B-6, Position of Signs, the MUTCD states that "Portable school signs shall not be placed within the roadway at any time." Logical extension of this statement would similarly prohibit plastic barrels in crosswalks.

Our Department does not allow any portable devices placed within the roadway surface on state highways other than for traffic control in work zones. We believe very strongly that necessary motorist warning to provide for safe pedestrian crossings can be provided by the use of standard traffic control devices coupled with appropriate levels of enforcement. Further, we feel the use of non-standard devices could expose the Commonwealth to liability in the case of an accident.

Accordingly, we ask that you inform your readers that the Massachusetts Department of Public Works does not allow the use of plastic barrels as pedestrian warning devices on State Highways, and we urge municipalities not to use them on local roadways.

Very truly yours,

Robert L. Shea, P.E.
Traffic Engineer
Mass. Dept. of Public Works

Pipe Culverts, Cont.

Corrugated metal and plastic pipe culverts should have adequate fill on them before traffic is allowed to pass over. Fills on top should not be less than 2 feet.

Inlet and Outlet Treatments

The treatment of culvert inlet and outlet is very important in terms of durability and performance. Inlets should be flared so as to effectively guide water into the culvert barrel, and reduce the chances of scour. Similarly, culvert outlets should be flared enough to distribute the flow over a wider opening, decreasing flow velocity and chances of erosion. Where applicable, wingwalls should be constructed as part of end treatment to improve flow and support embankment.

• REFERENCES

1) "Culverts - Proper Use and Installation," Wisconsin Transportation Bulletin, Transportation Information Center, University of Wisconsin, Madison, WI.
2) "Highway Drainage," Core Curriculum, U.S. DOT, FHWA, Dec. 1984.
3) "Installation Manual for Corrugated Steel Drainage Structures," National Corrugated Steel Pipe Association, Washington, D.C., 1987.

article contributed by Emmanuel Ofori-Darko, Research Assistant, University of Massachusetts.

PUBLICATIONS

NEW LISTINGS, CONTINUED

"Cracking and Seating of PCC Pavements Prior to Overlaying with Hot Mix Asphalt-State-of-the-Art" (6/84) Based on NAPA's IS-98 of the same name, this slide tape presentation describes the cracking and seating process, illustrates typical cracking equipment, crack pattern and piece size, seating, influencing factors, and more. Also lists states known to have conducted cracking and seating projects and procedures followed.

"Large Stone Mixes: A Historical Insight" (1/88) This publication reviews the history of large stone mixes and discusses the evolution of asphalt pavements from the early 19th century pavements to the Warren patents of the early 20th century and the development of the "Topeka" mix. Using lessons from pavement designs of the past, the author draws useful conclusions for strengthening today's HMA pavements through the use of large stone mixes. - 6 pp.

"Performance of Open-Graded 'Big Rock Mixes' in Tennessee and Indiana" (3/88) Pavement design, in terms of both mix and thickness design, has moved steadily toward dense-graded Hot Mix Asphalt. Twenty years ago, however; during the construction of the interstate system, Indiana and Tennessee constructed several pavements utilizing open-graded "Big Rock" HMA mixtures. A recent review and analysis of two of these projects has demonstrated that "Big Rock" Mixes can support heavy truck traffic and provide an economical alternative to dense-graded HMA base materials. - 10 pp.

"Pavement Life Cycle Costing" (2/87) Not all investments are equal; and since road and airfield pavements are usually investments of public funds, the economics of alternative pavement types should be analyzed carefully as a part of the pavement design process. This publication reviews life cycle costing parameters used by many specifying agencies and points out the strengths and flaws. While devising a technique that takes into account the very real costs of user delays and other often overlooked variables, it makes a strong case for Hot Mix Asphalt pavements. - 20 pp.

IN THIS ISSUE

The Baystate Roads Program, which publishes *Mass Interchange* each quarter, is a Technology Transfer (T2) Center created under the Federal Highway Administration's (FHWA) Rural Technical Assistance Program (RTAP). FHWA is joined by the Massachusetts Department of Public Works, the Department of Civil Engineering at the University of Massachusetts/Amherst, and local public works departments in an effort to share and apply the best in transportation technologies.

In addition to publishing *Mass Interchange*, the Baystate Roads Program facilitates information exchange by conducting workshops, providing reports and publications and videotapes on request, and offering one-to-one technical assistance on specific roadway issues. Because the program relies on input from many sources, inquires, articles, and ideas are encouraged.

To contact the Baystate Roads Program, please call Silvio Baruzzi at(413) 545-2604.

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