Country Roads & City Streets

WV Transportation Technology Transfer Center

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WestVirginiaUniversity.

Fiber Reinforced Polymer Composite Bridges of WV

Dr. Hoto Ganga Rao - Director, West Virginia Constructed Facilities Center

Dans Run Slab Bridge - An example of a bridge with FRP rebars

The use of Fiber Reinforced Polymer (FRP) Composites (glass fabrics with thermoset resins) for bridge construction is a new development in West Virginia. FRP composites have been the material of choice in the aerospace industry since the 1960s. However, it is only recently that glass FRP composites have gained popularity and acceptance as bridge materials of choice because of their high strength and stiffness to weight ratio, corrosion resistance, higher energy absorption, and competitive cost. In addition, the low self-weight of FRP composite bridge decks (approximately 15 - 20 lb/ft^2) has resulted in increased live load carrying capacity of old bridges after replacement of old concrete decks with the FRP decks. Indeed ever-increasing truck loads, public demands for durable bridges, and more expensive labor rates, are making FRP composite modular bridge systems the best choice for highway bridges.The development of stronger, stiffer, more durable, more economical, and consistently high quality engineered FRP composite aerospace products is one major reason for the emergence of FRP composite bridges. New types of engineered composites utilizing complex fabrics, resins, and structural systems make use of well established manufacturing processes such as pultrusion and vacuum assisted resin transfer molding to manufacture bridge deck modules. In West Virginia and surrounding states, the availability of glass fiber/fabric and thermoset resin materials for FRP composite bridges is abundant and the prices are becoming competitive with conventional materials at the component and system levels but not at the constituent material level. In other words, the structural performance of FRP composites per dollar is as good as that of the conventional materials.

In 1987, studies of FRP materials were initiated at the Constructed Facilities Center at West Virginia University (CFC-WVU) in cooperation with U.S. Department of Transportation-Federal Highway Administration (USDOT-FHWA) and West Virginia Department of Transportation-Division of Highways (WVDOT-DOH). The research dealt with the development of glass FRP

In This Issue

Country Roads and City Streets is a quarterly publication of the West Virginia Transportation Technology Transfer Center (T^2 Center). The purpose of this newsletter is to provide information that is beneficial to highway construction and maintenance personnel.

The material and opinions contained in this newsletter are those of the West Virginia Tranportation Technology Transfer Center, and do not necessarily reflect the views of the Federal Highway Administration or the WV Department of Transportation. Material contained in *Country Roads and City Streets* is a combination of original and borrowed material. Every effort has been made to ensure the integrity and accuracy of this material. However, the WV T^2 Center does not assume responsibility for any incorrect material.

reinforcing bars for concrete in lieu of steel reinforcing bars. Later, a number of new research and development concepts such as glass composite structural shapes, carbon composite plate bonding to steel, and carbon/glass fabric wrap around concrete and timber have been studied for possible use in highway structures.

Featured here are three categories of successful bridge applications in West Virginia: (1) FRP reinforcing bars for concrete (Dans Run Slab Bridge); (2) FRP structural shapes and systems including innovative joining mechanism (Wickwire Run Bridge); and (3) FRP wraps (East Street Viaduct).

Fiber reinforced polymer (FRP) composites offer good potential for use in bridge deck repair and replacements. In West Virginia, 12 bridges have been replaced with FRP composite decks while six bridges have been reinforced with FRP rebar in concrete decks, and four bridge beams and columns have been strengthened with FRP wraps. In addition, two bridges were built with all composites. The history of FRP bridges is still brief and much information regarding the long-term performance has yet to be gathered. We hope that new FRP composite bridges will exhibit the durability, provide the requisite economics, appeal to the aesthetic sense of the public, and finally grow significantly in their usage during the 21st century. At the time of this article, eight bridges are being monitored and all are performing well.

Additional examples of FRP bridges in West Virginia can be found in "Fiber Reinforced Polymer Composite Bridges of West Virginia," U.S. Department of Transportation-Federal Highway Administration, West Virginia Department of Transportation-Division of Highways, West Virginia Department of Transportation-Division of Highways, Compiled by: West Virginia University, Constructed Facilities Center, 2001.

BRIDGES WITH FRP REBARS

The Dan's Run slab bridge in Mineral County, constructed by WVDOT Division of Highways crews, was completed in November 2000. Average traffic on the bridge is less than 50 vehicles per day. The two-lane deck is 24 feet wide with W-beam guardrail on steel posts. The superstructure is an 18-inch cast-in-place concrete slab. (Please see picture on page 1 for side view of bridge.)

Driver's view of bridge

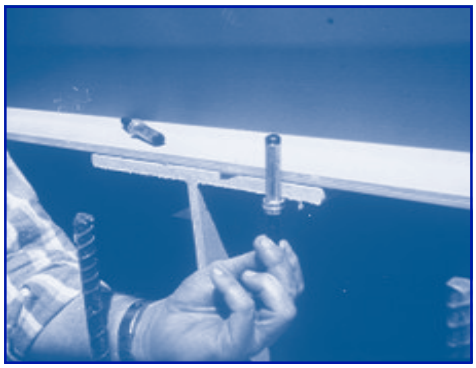
View of slab surface (half of the deck with FRP reinforcement and the remainder with steel).

Wickwire Run Bridge during construction

Placement of GFRP deck modules on steel girders

BRIDGES WITH FRP DECKS

Completed in July 1997, the Wickwire Run Bridge in Taylor County was constructed by WVDOT Division of Highways crews. Average traffic on the bridge is 100 vehicles per day. The superstructure of the 31-foot-long span consists of four steel girders at six-foot centers. The two-lane deck is FRP-Creative Pultrusion Superdeck(tm), approximately 22 feet wide. The railing is W-beam guardrail on steel posts.



Galvanized steel blind bolt (pop rivet)

NOTES:

- GFRP deck modules were connected to steel girders with galvanized steel blind bolts spaced at two-foot centers. Smaller size blind bolts were used to connect to contiguous deck modules in addition to using adhesive.
- Steel guiderail posts were connected to the exterior steel stringers.
- Concrete parapets are placed over the GFRP deck modules abutting the guiderail posts.
- As shown, heavy concrete parapets were placed on the deck modules during construction as counterweights while pulling the two contiguous modules tightly together.

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BRIDGES WITH FRP WRAPS

The East Street Viaduct in Parkersburg, Wood County, consists of a composite concrete slab with steel I-beam columns and concrete abutments on spread footings. The three-span, 134-foot-long structure handles an average daily traffic volume of about 19,000 vehicles on two roadway lanes. The abutment wall and viaduct roof were treated with a putty preparation and the concrete bases of the I-beams were wrapped with glass FRP to prevent further deterioration. A contractor completed the work in December 2000.

East Street Viaduct

Viaduct roof with filler

Abutment wall with primer

Finished left side with repair on right side

Concrete base wrapped with GFRP

Innovative ideas

Interdisciplinary programs

Integration of advanced technologies into current construction practices

These ideas, programs, and technologies make use of advanced composite materials and diagnostic tools with traditional engineering concerns, leading to the evolution of durable and economical facilities.

The Center's purpose is to conduct research, develop, and implement activities in areas that can help reduce or remedy deterioration of the nation's facilities, i.e., buildings, bridges, mass transit systems, military infrastructure, and many others.

Examples of research and development work carried out by the Center are:

- Development of composite and hybrid material components, structural systems and geo-systems for bridges, buildings, utility poles, and others;
- Preparation of design manuals for composite structures based on field evaluation;
- Manufacturing, characterization and application of recycled polymer composite materials;
- Corrosion/aging of composite and conventional materials;
- Development of nondestructive evaluation techniques with emphasis on infrared thermographs, acoustic emission, dynamic characterization and radar techniques;
- Crash-testing and evaluation of guide rail systems;
- Development of stress evaluation (mathematical) models for FRP composites;
- Cost analysis; and
- Promotion of activities in the field of emerging materials, including Technology Transfer.

The CFC has ongoing research projects with WVDOT, PennDOT, USDOT-FHWA, FRA, USDA-FS, S&PF, US Army, the Army Corps of Engineers, NSF, USDOE, and USDOD. Other CFC partners are composites industry, fiber industry, resin industry, engineered wood industry, instrumentation companies.

Ongoing projects at the Center are: Center of Excellence in Advanced Materials, Engineered Timber, Nondestructive Evaluation Activities, Corrosion, Recycling, Fiber Reinforced Polymer Composite Utility Poles, Modular Track Panels for the Mining Transportation Industry, National Historic Covered Bridge Preservation Research Program, Repair and Rehabilitate Wood Railroad Ties and Bridges with FRPs, Technology Transfer.

If you would like to learn more about Fiber Reinforced Polymer Composite Bridges of WV, or would like to obtain a copy of this final report, please contact the WV T² Center.

Ensuring Effective Traffic Control Devices with the Millennium Edition of the Man

By: the Federal Highway Administration MUTCD Program: Ernest Huckaby, Linda Brown, Charles Sears, Cherie L. Kittle and Louisa Ward

Effective traffic control devices - properly positioned and operational signs, signals and pavement markings, are one of the critical elements that ensure the safe and efficient operations of our streets and highways. In today's era of driver distraction and the controversy over cell-phone usage in the car, effective traffic control devices are more important than ever.

Traffic control devices provide the driver with guidance and instruction on how to safely and most effectively use the road. Uniformity of size, color, and shape also provide a consistent message to road users that they can expect to see the same traffic control application anywhere in the United States. Additionally, uniformity provides manufacturers of traffic control devices with consistent design standards.

The Manual on Uniform Traffic Control Devices is a national publication that outlines the proper usage of traffic control devices. Also known as the MUTCD, it contains national standards for the design, application, and placement of signs, signals, pavement markings, and other types of traffic control devices. It describes how traffic control devices are used in a variety of situations, such as :

- Local street operations;
- Bicycle and pedestrian crossings;
- School zones;
- Freeways and other highways; and
- Work zones.

The Federal Highway Administration (FHWA) publishes the MUTCD for national, state, and local transportation agencies and other public and private agencies responsible for transportation facilities. The MUTCD is an important tool in traffic operations that is most frequently used by traffic engineers when designing roads, during the installation and operation of devices, and for use in inspections. By using the MUTCD, transportation agencies have another resource to help optimize traffic performance and improve safety for road users.

The Millennium Edition of the MUTCD

On December 18, 2000, the FHWA published the Millennium Edition of the MUTCD. It is the sixth major revision since the first MUTCD appeared in 1927. Also known as the 2000 MUTCD, it is the first full-scale revision since 1978. It contains significant changes that will be further discussed in this feature. In general, the major changes fall into the following categories:

A new look for the MUTCD: The MUTCD was entirely reformatted for ease of use, and its language was standardized to reduce some of the confusion and vagueness of previous editions.

New parts: Two new parts were added to the 2000 MUTCD to address evolving transportation needs. Part five describes the use of traffic control devices for low-volume roads. Part ten addresses the needs of light-rail transit vehicles operating in the roadway and at grade crossings.

New signs and markings: The addition of new signs and markings helps to expand definition of traffic control devices. This feature highlights a few of the significant new signs and markings.

Pedestrians and bicyclists: As more of the population turns to alternative means of travel, these modes need to receive added emphasis to ensure their safety. The 2000 MUTCD provides additional guidelines for traffic control devices that serve the needs of pedestrians and bicyclists, including some suggestions for compliance with the Americans with Disabilities Act (ADA).

Keeping up with technology: The addition of Intelligent Transportation Systems (ITS) in the 2000 MUTCD reflects the increased application of advanced technologies within society and to the roadways. New and ongoing research will continue to drive changes in the MUTCD. This feature provides insight into some of the current research.

In contrast with the past, the 2000 MUTCD will be updated more frequently – potentially on a yearly basis – to keep pace with new developments and applications.

In yet another major break with the past, the FHWA chose to publish the official version of the 2000 MUTCD on its Web site (mutcd.fhwa.dot.gov).

Changes to the MUTCD: A New Look

In previous editions of the MUTCD, the language was sometimes vague and the layout of information confusing. The 2000 MUTCD provides a new, easy-to-use structure. The text is now divided into four categories: Standards, Guidance, Options, and Support.

Standards text indicates a regulation, which uses the verb "shall," and requires transportation engineers to follow the instructions provided. **Guidance** text is advice that is highly recommended and uses the verb "should." **Options** are provided for consideration and use the verb "may." **Support** text is added as discussion to provide useful details or descriptions for the traffic engineer.

The 2000 MUTCD uses section numbers in decimal format and page numbers in hyphen format. The 2000 MUTCD also has the date printed on every page, allowing for easier recognition of revision updates. Whenever revisions are published, this date will be changed to reflect the most recent version.

The most obvious format change is the availability of 8.5 x 11 inch, loose-leaf pages as well as the traditional perfect-bound format. This new format is designed to allow ease of inserting revisions into a three-ring binder. A separate Table of Contents is included with each chapter and a new one will be issued with each revision.

Next Steps for Traffic Engineers

Now that the 2000 MUTCD has been released, what impact does it have on the jobs of traffic engineers around the United States?

First, sufficient changes to the MUTCD suggest it will be vital for traffic engineers to frequently refer to this new edition. Many of the changes in this edition may make it easier for traffic engineers to do their jobs, or it may help them better solve traffic problems.

Second, by January 2003 the 2000 MUTCD's provisions will become law. The following are important dates to keep in mind:

The 2000 MUTCD was published on December 18, 2000;

The 2000 MUTCD officially became effective on January 17, 2001;

States must adopt the provisions of the 2000 MUTCD within two years, or by January 17, 2003. This is the date by which most traffic control devices must be in compliance with the 2000 MUTCD. States have the ability to adopt their own version of the 2000 MUTCD; however, traffic engineers will find that the 2000 MUTCD sets the minimum requirements; and

There are extended compliance dates for some of the new traffic control devices. These dates are longer than the two-year adoption period. The FHWA provides these extended periods to balance the economic impact to state and local agencies. Please see the Extended Compliance Dates list on the next page. This list can also be found on the MUTCD web site.

The MUTCD is an important tool for traffic engineers. It provides a common language to communicate with all road users to help ensure the safety and efficiency of the roadway system. For the latest MUTCD information, please visit the MUTCD web site at: mutcd.fhwa.dot.gov.

Please contact Mike Blankenship at the West Virginia T² Center if you have any additional questions regarding the new MUTCD regulations.

Check out these websites for more MUTCD information.

AASHTO -
www.aashto.org

ATSSA -
www.atssa.org

ITE -
www.ite.org

Government Printing Office -
www.gpo.gov

MUTCD Web Site -
www.mutcd.fhwa.dot.gov

Extended MUTCD Compliance Dates

Section 2B.04 — STOP Sign
Compliance period of 3 years
January 17, 2004

Section 2B.16 - Reduced Speed Ahead Sign
Compliance period of 7 years
January 17, 2008

Section 2B.32 - ONE WAY Sign
Compliance period of 7 years
January 17, 2008

Section 2C.02 - Application of Warning Signs
Compliance period of 7 years
January 17, 2008

Section 2C.23 - Pavement Ends Symbol sign (W8-3a)
Compliance period of 10 years
January 17, 2011

Section 2C.24 - Shoulder Signs
Compliance period of 10 years
January 17, 2011

Section 2C.37 - Crossing Signs
Compliance period of 10 years
January 17, 2011

Section 2D.38 - Letter Size of Street Name Signs
Compliance period of 15 years from Jan. 9, 1997
January 9, 2012

Section 2E.29 - Interchange Exit Numbering
Compliance period of 7 years
January 17, 2008

Section 2E.31 - Advance Guide Signs
Compliance period of 7 years
January 17, 2008

Section 2F.05 - Size of Lettering
Compliance period of 10 years
January 17, 2011

Section 3B.01 - Yellow Centerline and Left Edge
Line Pavement Markings and Warrants
Compliance Date: January 3, 2003

Section 3B.07 - Warrants for Use of Edge Lines
Compliance Date: January 3, 2003

Section 4E.06 - Accessible Pedestrian Signals
Compliance period of 4 years
January 17, 2005

Section 4E.08 - Accessible Pedestrian Signal Detectors
Compliance period of 4 years
January 17, 2005

Section 7B.08 - School Advance Warning Signs
Compliance period of 10 years
January 17, 2011

Section 8B.02 - Highway-Rail Grade Crossing (Crossbuck) Sign
Compliance period of 10 years
January 17, 2011

Section 9B.04 - Bicycle Lane Signs
Compliance period of 5 years
January 17, 2006

Section 9B.15 - Bicycle Crossing Warning Signs
Compliance period of 10 years
January 17, 2011

Section 9 - Deletion of Preferential Lane Symbol (Diamond) for Bicycles and Pavement Markings
Compliance period of 5 years;
January 17, 2006

Section 10 - Automatic Gates, Flashing-Light Signals, and Blank-Out Signs
Compliance period of 5 years;
January 17, 2006

Section 10C.11 - Highway-Rail Advance Warning Signs: Removal of Existing W10-6 Series Signs
Compliance period of 5 years;
January 17, 2006

7th Annual Eastern Winter Road Maintenance Symposium and Equipment Expo

The Eastern Winter Road Maintenance Symposium and Equipment Expo will take place September 4th and 5th in Charleston, WV at the Charleston Civic Center. This is your chance to see in person the latest equipment and technology available for winter road maintenance. (Yes. Real trucks. Real Plows. Heavy Equipment. All under one roof.) In addition to the equipment and other exhibitors, Thursday's program consists of three different tracks of sessions on topics ranging from Using Natural Brines, to Implementing Advanced Technology, to an Anti-Icing Roundtable.

To further entice you, come to Charleston on Wednesday for an early exhibit preview and attend WinterFest 2002. Winterfest 2002 is a very casual southern-style reception. This reception will feature many regional delicacies, such as venison and catfish, along with entertainment. This is a great networking opportunity for all attendees and exhibitors. WinterFest 2002 gets underway Wednesday, September 4 from 6:30 pm until 9:00 pm, across the street from the Civic Center, at the Marriott Pavilion.

This entire program is offered *free of charge*. That's right. There is no Participant Registration fee. It's all FREE!

Pre-registration of all participants, although unlimited, is required by August 20 to assure that adequate materials are on hand for all attendees. Pre-registration is also required for entry to Winterfest 2002 and to be eligible for the "Olympic" Door Prize drawing.

To learn more about this event, visit the following web site: **www.easternsnowexpo.org** or call Kim to receive a copy of the program.

You don't want to miss this event!

Remember:

Early Arrival Exhibit Preview - Wednesday, Septemer 4, 2002

One-Day Symposium - Thursday, September 5, 2002

Since WV is hosting this Expo, the Center will not hold its annual Snow and Ice Control Workshop at Jackson's Mill. This workshop will resume September 2003. Watch for upcoming details.

- Learn how to improve your highway agency's response to winter weather transportation problems
- Learn how to get more from what you have
- Network with winter maintenance specialists from States east of the Mississippi River and beyond
- Examine the latest equipment and techniques available to help in snow and ice control, pavement rehabilitation, maintaining an appropriate fleet, and materials storage.

Eastern Winter Road Maintenance Symposium and Equipment Expo Program

A showcase of Technologies and Practices

Preliminary Symposium Program

Thursday, September 5, 2002

7:00 AM Registration Open - Complimentary Continental Breakfast

8:00 AM Opening Remarks

8:30 AM General Session: Going for the Gold

Snowforecasting & Operations: Olympic Style 2002; Steve Conger, Utah DOT

Drawing for "Olympic Door Prize: for those who are pre-registered"

	Canaan Valley Room: Managers Track	Snowshoe Room: Operator's Track	Winterplace Room: General Track
9:30	**Implementing Advanced Technology** *The Model Maintenance Truck* John, Scharffbillig, MNDOT	**Canadian Nat'l RWIS** Paul DeLannoy Meteorological Service of Canada	**AASHTO Anti-Icing/RWIS Computer Based Training** Lee Smithson, AASHTO
10:30	**Break**	**Break**	**Break**
11:00	**ITS and Winter Operations Scanning Tour of Japan** Joe Doughtery, NYDOT Dan Roosevelt, VDOT	**Eastern Snow Rodeo?** Charlie Bull, MD SHA	**Privatization and Leasing** *Is either option right for you?* Jack Corley, VMS

12:00 - 1:00 PM Grab Lunch and Network

1:00	**Canadian "Toxic" Road Salt Declaration** TBA Canadian EPA	**Experience With Mag Chloride** Paul Pisano, FHWA	**Using Natural Brines** Terry Hough, City of Morgantown Mike DeMary, Fairmont DPW
2:00	**Break**	**Break**	**Break**
2:30	**Equipment Manager Roundtable** "Maintenance of Fleets-Lifecycles-Experience with Advanced Features" *Facilitators:* Bob Stanton, Polk County, FL John Scharffbillig, MNDOT	**Anti-Icing Roundtable** "The User's Perspective" *Facilitators:* Tom Martinelli, WISC DOT Corey Johnson, MN DOT	**Procurement Roundtable** "Litigation and Specifications" *Facilitators:* Brandon Long, Illinois DOT

3:00 Exhibit Area Closes

4:30 Roundtables End

New Videos Available for Loan

Maintaining the Ditch and Cross Surface Drains

Produced by: USDA Forest Service Engineering San Dimas Technology and Development Center, 2002

This video provides comprehensive instructions for correctly constructing and maintaining ditches, culverts and various surface cross drains. Highlights rolling dips, earthen water bars and interceptor dips. Covers heeling the ditch, pulling the ditch, maintaining surface cross drains, rolling drain dips, interceptor dips, earthen water bars, and open-top drainage devices.

Reading Beyond the Traveled Way

Produced by: USDA Forest Service Engineering San Dimas Technology and Development Center, 2002

This video considers the natural functions happening beyond the roadway (rain, erosion) and how to use that knowledge before beginning maintenance operations to help minimize significant impacts on the road. Covers gullies, cracks and slumps, roadside ditch, ditch relief culverts, live stream culverts, and brush removal.

Reading the Travel Way

Produced by: USDA Forest Service Engineering San Dimas Technology and Development Center, 2002

This video focuses on understanding what the condition of the road is and provides insights on how to proactively avoid costly repairs by properly addressing the road in its current condition. Shows rutting, washboarding, potholes, destroyed road template, cracks, flour, loss of surfacing, excessive vegetation, water bypassing surface cross drains, damaged or filled cattle guards, damage to bridges, and damage to fords.

Forest Roads and the Environment

Produced by: USDA Forest Service Engineering San Dimas Technology and Development Center, 2002

This video provides an introduction to the maintenance of low-volume roads, highlighting issues that benefit from proper maintenance activities, such as water temperature, fish habitat and aggregate surfacing loss.

Smoothing and Reshaping the Traveled Way

Produced by: USDA Forest Service Engineering San Dimas Technology and Development Center, 2002

This video covers detailed step-by-step processes used for both smoothing and reshaping a road. Covers crowned, insloped and outsloped roads as well as transition sections.

CD's, Videos, and Publications are available from our lending library for a period of two weeks at no charge. To borrow material from our library, please contact Kim at 304-293-3031 x 2612 or E-mail kcarr@wvu.edu.

The West Virginia T^2 Center is a part of the nationwide Local Technical Assistance Program (LTAP), which is funded by the Federal Highway Administration. The Center also receives funding from the West Virginia Department of Transportation.

Mission:

The mission of the West Virginia T^2 Center is to foster a safe and efficient transportation system. The T^2 Center's mandate is to improve the transportation system by improving the professional skills of those involved in highway design, construction and maintenance, and to act as a resource for them by keeping up-to-date training libraries and constantly seeking/developing new technologies.

Overall Goal:

The Center's overall goal is to improve the transportation system by focusing on professional training, technical assistance, and information dissemination.

To achieve this goal, the WV T^2 Center does the following:

- Provides on-site training and demonstrations
- Publishes a quarterly newsletter
- Maintains a video and publications library
- Provides technical assistance via e-mail, telephone, fax, mail, or site visits

In Brief With Ron Eck

In the past, technology moved from research to practice via simple diffusion of knowledge. Today, however, the rapid onset of new technology and research information requires a more effective and efficient process. Technology transfer provides this systematic approach.

For about 15 years, the Constructed Facilities Center at WVU, under the leadership of Dr. Hota Ganga Rao, has been investigating the applications of fiber reinforced polymer (FRP) composites for bridge construction. That work has proceeded from theoretical and laboratory studies to the actual construction and monitoring of such bridges at a number of locations in the state. Several of the structures are highlighted in this issue. We're pleased to help publicize these projects but would welcome the opportunity to foster the adoption and implementation of this technology. While published articles like this can raise awareness, the technology is far more likely to be transferred if one can see it first-hand (e.g., through field trips and demonstrations) or can talk to those who actually constructed and/or must maintain it (e.g., through workshops and teleconferences). Which of these mechanisms is most effective for you?

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Please share this newsletter with others.

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- ❒ Council Members
- ❒ Public Works Dept.
- ❒ Road Crew
- ❒ Managers
- ❒ City Engineers
- ❒ Mayors
- ❒ Others