

Volume 56 No. 1 Spring 2004

concretepipe news

The Magazine of the American Concrete Pipe Association

Yes!

In My
Backyard...

RCP and Boxes A Site to Behold.

- Institute of Religion Campus Built On Rock-Solid Infrastructure
- Research Suggests Conservative Design of Concrete Box Culverts
- PIPEPAC Upgrade Improves Ease Of Use and Applications



This issue:

Volume 56, Number 1
Spring 2004

Concrete Pipe News is published four times each year by the American Concrete Pipe Association. It is designed to provide information on the use and installation of precast concrete pipe products for a wide variety of applications, including drainage and pollution control systems. Industry technology, research and trends are also important subjects of the publication. Readers include engineers, specifiers, public works officials, contractors, suppliers, vendors and members of the American Concrete Pipe Association.

American Concrete Pipe Association Staff

John J. Duffy
President

Josh Beakley
Director of Technical Services

Matt Childs
Director of Engineering Services

Wanda Cochran
Administrative Assistant

LaHonda Holle
Administrative Assistant

Wendy Lambert
Controller

Media Task Group

Bill Gardner
*Madison Concrete Pipe, Inc.
Madison, Wisconsin*

Robert Powers
*Inland Pipe Limited
Edmonton, Alberta*

Bill Hobson
*N C Products
Raleigh, North Carolina*

Mike Beacham
*Rinker Materials, Hydro Conduit
Denton, Nebraska*

Robert Ryan
*Master Builders, Inc.
Cleveland, OH*

Steve Berlo
*Scituate Concrete Pipe Co.
Scituate, MA*

Contract Editorial Staff

A. Grant Lee
*AGL Marketing Limited
Executive Editor*

Gary Wilder
*Wilder Studios
Production*

Published by:

American Concrete Pipe Association
222 W. Las Colinas Blvd., Suite 641
Irving, Texas 75039-5423
Phone: (972) 506-7216
Fax: (972) 506-7682
E-mail: info@concrete-pipe.org
www.concrete-pipe.org



Opinions expressed by authors other than staff of the American Concrete Pipe Association do not necessarily reflect the official positions or policies of the Association. No part of this publication may be reproduced or transmitted by any means without written permission from the publisher.
© Copyright 2004 ACPA

Table of Contents

Regular Departments

"Precast Concrete Drainage Products Are Intrinsic Elements of Sustainable Development" 3
From Association President John J. Duffy

Industry Spotlight 4

The Industry Spotlight features Robert J. O'fill, Vice President and General Manager (Retired), Ameron International Protective Linings Products, an expert on protective liners for concrete drainage products with decades of experience producing RCP in the U.S.A. and abroad.

Features

Precast Concrete Pipe and Box Sections Installed "Close To Home" 6

The recent expansion of the drainage system in the Las Colinas area of Irving, Texas, within the shadows of the American Concrete Pipe Association's headquarters, includes 1,500 feet of Class III RCP of various diameters and approximately 1,000 feet of precast reinforced concrete box sections.

Institute of Religion Built On Rock-Solid Infrastructure 9

The specification for a stormwater detention system at the campus of the new Salt Lake University Institute of Religion (originally specified as a 72-inch diameter concrete pipe) was changed to four rows of box sections (13-feet x 6-feet x 8-feet) approximately 120 feet in length.

Research Suggests Conservative Design of Concrete Box Culverts 11

University of Toronto research involving 12 major experiments on actual box culverts was undertaken to develop an understanding of the shear resisting mechanisms for such structures. The crack development, reinforcement strains, and specimen deformation were compared to the results of extensive nonlinear finite element analysis using the computer modeling techniques developed at the University of Toronto. Discussion presented in the report called, "Shear Behaviour of Concrete Box Culverts: A Preliminary Study" by R.A. Yee, E.C. Bentz, and M.P. Collins, identifies areas of weakness and lack of clarity in the current codes governing box culvert design.

*On the cover:
Construction of the connecting section of Las Colinas Boulevard required a crossing of a portion of Lake Carolyn's northwesterly shoreline. Design engineers specified a box storm sewer system with three reinforced concrete pipe laterals to carry the anticipated storm water discharge from the new development area to Lake Carolyn. The box sewer would also serve as a culvert [beneath the extension of Las Colinas Boulevard] to the outfall structure into the Elm Fork of the Trinity River.*





John J. Duffy

Precast Concrete Drainage Products Are Intrinsic Elements of Sustainable Development

The popular concept of *Greening of America* tends to focus on “green” products that conserve natural materials. Greening of products, services and business is good for all North Americans, and peoples of other lands. But few realize that truly “sustainable” products carry the successes of the green movement.

Greening of products often does not take into account life cycle analysis and durability of products used in our buried infrastructure. Satisfaction often ends with the implementation of the three Rs of waste management - reduce, reuse, recycle. This is the core of greening to many North Americans. Few realize that recycling certain plastic products, for example, into conduits used for gravity pipe is not in keeping with the intent of the green movement.

The federal government weighed in on *greening* and defined the purchase of green

products saying that “environmentally preferable products are products and services that have a lesser or reduced effect on human health and the environment when compared to other products and services that serve the same purpose. This comparison may consider raw materials acquisition, production, manufacturing, packaging, distribution, reuse, operation, maintenance, or disposal of the product or service.” - (Executive Order 13101, Greening the Government Through Waste Prevention, Recycling, and Federal Acquisition, September 16, 1998)

The concept of sustainability and the long-term impact of durable products on society are not clearly understood. Concrete pipe and boxes used for the nation’s buried infrastructure takes the green movement and the meaning of sustainable development to new heights.

The United Nations Council on Sustainable Development published the definition of sustainable development in the *Global Biodiversity Assessment (1995)* as “development that meets the needs and aspirations of the current generation without compromising the ability to meet those of future generations.” The President’s Council on Sustainable Development established in 1993 by Presidential Executive Order #12852, adopted the definition of “Sustainable Development” drafted by The World Commission on Environment and Development in *Our Common Future (1987)*, as “... to meet the needs of the present without compromising the ability of future generations to meet their own needs.”

Sustainable development calls for improving the quality of life for all the world’s people without increasing the use of natural resources beyond the Earth’s carrying capacity. Efforts to build a truly sustainable way of life require the integration of action in three key areas: economic growth and equity; conserving natural resources and the environment; and social development. (World Summit on Sustainable Development, Johannesburg, South Africa 26 August-4 September 2002).

The concrete pipe industry is well aware

continued on page 14



Robert J. O'ffill, Vice President and General Manager (Retired) Ameron International Protective Linings Products Brea, California



Robert (Bob) O'ffill officially retired on November 17, 2002 after 40 years of service. Now as a consultant, he continues serving the company he managed for 15 years as Vice President and General Manager. Throughout 2003,

Bob shared his expertise in the field of sanitary sewer and wastewater treatment while assisting in the training of the succession management team. He now offers his services through "Or Approved Equal", a consulting firm.

A graduate of Kansas University, Bob began working with Ameron as a Sales Engineer in the Amercoat Division in 1963. He worked in many levels of management until he became Vice President in 1986. He is no stranger, either, to the wastewater treatment industry in the Middle East. There, he saw many instances

of sewer corrosion while living in Saudi Arabia for three years with his wife Diane.

Throughout his career, Bob has witnessed the evolution of protective liners for concrete drainage products, and the acceptance of T-Lock® products. Used worldwide, T-Lock is commonly associated with very aggressive environments where hydrogen sulfide present in the pipelines reacts to form sulfuric acid. Ameron has partnered with concrete pipe producers and the ACPA over many decades to develop products that work well in combination with concrete pipe. Mr. O'ffill agreed to reflect upon his experiences to help us document the development of a proven product, and its evolution with concrete pipe technology.

Q: *T-Lock is widely used throughout North America where aggressive environments are likely to impact the performance and durability of reinforced concrete pipe. Please comment on the early development of T-Lock and its acceptance in the marketplace.*

O'ffill: Ameron has been a producer of concrete pipe for over 95 years, beginning in Los Angeles in 1907. Ameron was thus on the front line as the city grew and became a hot bed of sewer corrosion in those early years. So it was no surprise the City approached Ameron in the 1930s to work together to solve the problem. It took years of research and development by Ameron's chemists and City engineers to come up with the answer in 1947 - T-Lock®.

Early installations in San Diego and Los Angeles were watched carefully by agencies, and the results were outstanding. With the expert marketing of a few fellows like the affable Percy Dykes, T-Lock soon became known throughout the sanitary engineering community. Percy was recognized globally as "Mr. T-Lock", and that pseudonym is now being passed to Gabe Perez.

Q: *Please comment on T-Lock quality assurance programs and continued development of such programs.*

O'ffill: Contractors are not commended for their quality of work on a regular basis, if inspection of the installation is not ongoing. At the same time, it is not fun to climb into manholes and journey some distance into a sewer pipe to perform an inspection. There is a very natural lack of enthusiasm by engineering and agency personnel to crawl through sewer lines. Ameron personnel have always provided excellent jobsite training to pipe producers and contractors, but staff is unable to be at numerous on-going projects at all times.

Starting with the L.A. County Sanitation Districts, specifications were developed to train and employ full-time professional third party inspectors on their projects. The results were better than expected, and this approach to quality assurance is rapidly spreading.

Q: *Please comment on your experience in the Middle East and the need for protective liners.*

O'ffill: About 25 years ago, Ameron expanded its pipe producing operations into the Middle East, building several plants in Saudi Arabia, United Arab Emirates, and more recently Egypt. At times, Ameron personnel numbered in the hundreds at those locations, so it was a bonus that they learned of the need for T-Lock. Consequently, hundreds of miles of T-Lock-lined reinforced concrete pipe have been installed over the years. But it isn't just the Middle East that presents a market. Many miles of lined pipe have been installed in Australia, Thailand, Canada, Mexico and other countries.

Q: *In your 40 years of experience in the wastewater collection industry, what is the greatest change in technology that you*

have witnessed?

O'ffill: There are two that can't be overlooked. The first took place when Ameron, working with two of the biggest pipe producers, learned how to produce "tubes" of T-Lock that would slip neatly over the vertical core of the pipe-making molds. This was harder than it sounds because of the minute dimensional differences in each pipe plant's equipment pool. But, the effort to perfect the technology was well worth it as the cost of mating the T-Lock to the concrete pipe was reduced by more than half.

The second is the giant stride made by the equipment producers such as Besser, Pedershaab and others. The improved quality of machine-made drycast concrete pipe together with T-Lock lining is evidenced by its widespread acceptance throughout North America, and indeed around the world.

Q: *Ameron has been an Associate Member of the American Concrete Pipe Association decades. Please comment on the value of membership and what you believe is required keep long-term members such as Ameron.*

O'ffill: While Ameron is both a Producer and Associate Member, I'll answer from the latter perspective. Simply, it is the face-to-face personal relationships that become possible over the years. In our highly competitive marketplace, suppliers and producers must cooperate closely to improve technology and understand applications, or both will lose business opportunities. And so, it comes down to trusting each other when it is crunch time. The various programs and meetings of the ACPA were extremely important to me in developing those relationships that led to cooperation and trust. Keep up the fine work you are doing, and thank you for asking. ☺

Precast Concrete Pipe and Box Sections Installed

CLOSE TO HOME

By Dale Pruden, Sales Manager - DFW Gravity Pipe
Hanson Pipe & Products, Inc., Grand Prairie, Texas
972-262-3600


The old saying goes, “The grass is always greener on the other side of the fence.” That adage doesn’t hold water when it comes to stories for *Concrete Pipe News*. The recent expansion of the drainage system in the Las Colinas area of Irving, Texas – within the shadows of the American Concrete Pipe Association’s headquarters – vividly illustrates this point.

Las Colinas promotes itself as “The Premier Business Address of the Southwest.” The 12,000 acre development boasts corporate headquarters for such giants as Verizon (formerly GTE), Kimberly-Clark, Exxon/Mobil Corporation, Zales Corporation, Fidelity Investments, Boy Scouts of America, Mothers Against Drunk Driving – and the American Concrete Pipe Association. Established in 1973, the reclaimed wetland community has weathered the ups-and-downs of

the Texas real estate market to provide formidable competition to both Dallas and Fort Worth for corporate relocations.

Over the next two years, 1,300 family units will be added to the model community. Four developers are moving ahead with apartment projects in the South Urban Center, adjacent to the offices of the American Concrete Pipe Association. Lake Carolyn, a 125-acre man-made lake, is central to the marble-curbed community. The lake serves as the detention system for floodwaters from the West Fork of the Trinity River as well as an aesthetic masterpiece, bringing unity to the various architectural styles and corporate campuses located throughout the sprawling business park. A massive network of storm sewers, channels, and canals thread through the waterfront city.

In addition, an elevated rubber-tired tram system (locally dubbed “people mover”) runs throughout the Las Colinas property, connecting outlying buildings to the Urban Center



1,500 feet of Class III RCP of various diameters and approximately 1,000 feet of precast reinforced concrete box sections installed within sight of ACPA offices.



Engineers specified a box storm sewer system with three reinforced concrete pipe laterals.

where restaurants, retail shops, banking center and other amenities are located. Plans call for the “people mover” system to connect with the future extension of the Dallas Area Rapid Transit (DART) system through the Urban Center.

To service a future transit village, proposed Irving Convention Center and new apartment properties on the northern edge of Las Colinas, an extension of Las Colinas Boulevard was required along with associated underground utilities including water mains, sanitary sewers, storm sewers, power, and communications conduits. Much of the storm water management and collection system draining into and out of Lake Carolyn is reinforced concrete pipe and boxes. The long-term performance of precast concrete drainage products continues to influence the decision to include such products in the servicing of each new phase of development.

In June 2003, Site Concrete, Inc, Grand Prairie, Texas, was awarded contracts to extend Las Colinas Boulevard. The first project extends Las Colinas Boulevard from Fuller Drive (adjacent to ACPA’s offices in the Millennium Center Building) to SH 114 service roads. The 3/4-mile connection between the westerly end of Las Colinas Boulevard and SH 114 is required for the future development of

Las Colinas.

The second project awarded is on the northerly end of Las Colinas Boulevard. This project extends Las Colinas Boulevard across Lake Carolyn to connect with Rochelle Boulevard. It will also extend and connect Lake Carolyn Parkway with Las Colinas Boulevard. This project is needed so that Lake Carolyn can be easily traversed by existing residents and office workers, as well as the people expected to reside in the new apartment complexes and businesses. The contract also included improvements to Fuller Drive, which will extend Las Colinas Boulevard to the service roads of State Highway 114.

Hanson Pipe & Products, Inc. supplied the reinforced concrete pipe (RCP) and precast boxes from its Grand Prairie, Cedar Hill and



Box storm sewer also serves as a cross culvert beneath the extension of Las Colinas Boulevard.

Fort Worth plants. There were no delays in delivery of the product that included approximately 1,500 feet of Class III RCP of various diameters and approximately 1,000 feet of precast reinforced concrete box sections.

“Site Concrete chose Hanson Pipe & Prod-

ucts to provide reinforced concrete pipe and box sections for the Las Colinas projects because of our reputation for quality, competitive pricing and commitment to service,” said Dale Pruden, Sales Manager for Hanson’s gravity pipe operations in the DFW area. “Our facility’s close proximity to the project enabled us to provide timely delivery to the site with a self-unloading truck for the RCP,” said Pruden.

Pruden went on to say, “By choosing precast box culverts, Site Concrete was able to avoid costly delays and stay on schedule. Likewise, Glenn Engineering had the confidence to specify a product with a long design life that was suitable for the most challenging conditions.”

Construction of the connecting section of Las Colinas Boulevard required a crossing of a portion of Lake Carolyn’s northwesterly shoreline. Design engineers specified a box storm sewer system with three reinforced concrete pipe laterals to carry the anticipated storm water discharge from the new development area to Lake Carolyn. The box sewer would also serve as a culvert beneath the extension of Las Colinas Boulevard to the outfall structure into the Elm Fork of the Trinity River.

[continued on page 14](#)

Project:	Las Colinas Blvd. Extension
Owner:	City of Irving, Texas
Design Engineer:	Glenn Engineering Irving, Texas Mike Glenn, Engineer
Contractor:	Site Concrete, Inc. Grand Prairie, Texas Gregg McFadden, Project Manager
Quantities:	610 feet of 18-inch diameter RCP CL-III tongue and groove (T&G) 194 feet of 24-inch diameter RCP CL-III T&G 45 feet of 27-inch diameter RCP CL-III T&G 20 feet of 33-inch diameter RCP CL-III T&G 45 feet of 36-inch diameter RCP CL-III T&G 94 feet of 42-inch diameter RCP CL-III T&G 446 feet of 48-inch diameter RCP CL-III T&G 112 feet of 54-inch diameter RCP CL-III T&G 930 feet of (5-foot x 5-foot) RCB Sections 98 feet of (10-foot x 10-foot) RCB Sections
Producer:	Hanson Pipe & Products, Inc. Grand Prairie, Texas Dale Pruden, Sales Manager - DFW Gravity Pipe

Hanson Pipe & Products, Inc. is a diversified manufacturer of concrete pipe and a variety of supporting products including manholes, drainage structures, box culverts, bridge components, retaining walls and concrete block. Its plant locations throughout North America enable the company to serve the most rapidly growing parts of the U.S. and Canada. Hanson is an international building materials company. It is one of the world’s largest producers of construction aggregates, and concrete gravity and pressure pipe, precast concrete, and is the leading manufacturer of facing bricks in Europe. See www.hansonconcreteproducts.com for details.



Institute of Religion Campus

Built On Rock-Solid Infrastructure

By Phil Gale

Geneva Pipe Company, Orem, Utah
801-225-2416

A stormwater detention system constructed of precast concrete box sections provides rock solid infrastructure for the campus of the new Salt Lake University Institute of Religion building. There was never any doubt in the minds of the engineers at Great Basin Engineering North that precast concrete products would be used for stormwater quantity and quality management instead of a surface stormwater management pond. The challenge was whether to go with reinforced concrete pipe, or precast concrete boxes for the underground storage facility.

Sitting high on a mountain bench on the eastern side of the Salt Lake Valley, the 114,500-square-foot building located adjacent to the University of Utah campus can accommodate an enrollment of 10,000 participants. The building has two separate wings connected by a glass-enclosed atrium. Each wing includes a chapel for Sunday worship and multipurpose areas for sports and other student activities. The complex also houses 32 classrooms and 38 offices for staff use. Other features include a library and study areas, lounges, a game room and a service area for prepared foods.

The size and scope of this project and the amount of runoff it would generate were of great concern. Below the mountain bench,



RCP specification changed to precast concrete boxes.





Stormwater controlled with four rows of box sections.



Geneva Pipe met with the contractor and revised the specifications for the buried structure. They elected to construct a storage system comprised of four rows of box sections (13-foot x 6-foot x 8-foot), approximately 120 feet in length. The box stormwater storage facility offered more efficient storage and simplified the project with fewer connections. The design also allowed for closer spacing of the boxes, thereby reducing the excavation area by almost half. The box system removes all the liability issues associated with aboveground ponds, and the owner realized substantial savings in construction costs – savings that will continue due to the low cost maintenance of the concrete system.

[continued on page 15](#)

there are a numerous communities whose storm systems would not be able to handle the additional runoff from the new campus during a major storm event. The owner and the engineer preferred not to have an above ground detention pond, since ponds require a great amount of surface area for water detention, a high level of maintenance, and there is a significant liability aspect attached to ponds serving as stormwater detention and quality systems. A precast concrete underground detention system was considered best for this application, located beneath the proposed parking area.

The design engineer originally specified a large-scale 72-inch diameter concrete pipe detention area. After the contract was awarded, the contractor Reynolds Bros. approached the engineers at Geneva Pipe and expressed concern about the length of the concrete pipe runs, and the number of specialty connections required to complete the project. The contractor also noted that there was a possibility of pipe creep that would result in leaks in the structure and the related problem of sealing all of the specialty pieces.

Engineers at Great Basin Engineering and

Project:	Salt Lake University Institute of Religion Salt Lake City
Owner:	The Church of Jesus Christ of Latter-Day Saints Salt Lake City
Consulting Engineer:	Great Basin Engineering North Ogden, Utah David Waldron P.E., Project Engineer
General Contractor:	Bud Bailey Construction Salt Lake City, Utah John Hay, Superintendent
Underground Contractor:	Reynolds Bros. Murray, Utah Mike Wahlin, Project Manager:
Quantities:	480 feet of 13-foot x 6-foot x 8-foot box sections (80 sections)
Producer:	Geneva Pipe Company Orem, Utah Fred Klug, Production Steve Conk, Sales

RESEARCH SUGGESTS CONSERVATIVE DESIGN OF CONCRETE BOX CULVERTS

By Paul Smeltzer, P.Eng.

Ontario Concrete Pipe Association

905-631-9696, and

*Evan Bentz, Ph.D., Assistant Professor, Department
of Civil Engineering, University of Toronto*

Precast concrete box culverts are primarily used to carry streams beneath roadways, as conduits for buried stormwater or sanitary sewers, and as access tunnels under road and rail infrastructure. It is critical to public safety that these structures not undergo brittle shear failures. If the shear reinforcement in these structures is excessive, however, it is a waste of resources and contrary to principles of sustainable development.

To resist bending moments caused by earth pressures and vehicle loads, precast concrete box units contain longitudinal and circumferential steel reinforcement near the inside face and the outside face of the box. Where excessive loads are experienced, due to depth of cover or other factors, shear steel reinforcement is added to the design. While such shear reinforcement requires more steel, it is also difficult to place and can significantly increase production time and energy resources during the dry cast production process.

Preliminary research at Centennial Concrete Pipe (now Hanson Pipe & Products Canada, Inc.) in late 2000, witnessed by Gamsby and Mannerow Limited, suggested that box specimens produced with and without a new type of shear reinforcement failed at a load between 820 and 1000 KN. The engineer reported that the testing did not establish the usefulness of the new type of shear reinforcement. The testing also indicated that there was a need to investigate traditional formulae and codes calling for the level of shear reinforcement currently required in box units.

Canada is fortunate to have Professor

Michael Collins, a world leader in the consideration of shear in concrete, as a faculty member at the University of Toronto (U of T). Prompted by the research at Centennial, Dr. Collins was approached by the Ontario Concrete Pipe Association (OCPA) to propose a research project on shear steel design. In addition, after Harvey Pelligrini of Materials and Manufacturing Ontario (MMO) was contacted on this landmark research to determine the interest of the province, MMO quickly agreed to partner on the project. Rounding out the research partners were the Natural Sciences and Engineering Research Council (NSERC), the OCPA, Con Cast Pipe Limited, Hanson Pipe & Products Canada, Inc., M-Con Products Inc., and Munro Concrete Products. A research proposal presented by Dr. Collins was accepted in 2003 and the results released in January 2004.

The U of T research involved 12 major experiments on actual box culverts to develop an understanding of the shear resisting mechanisms for such structures. The crack development, reinforcement strains, and specimen deformation were compared to the results of extensive non-linear finite element analysis using the computer modeling techniques developed at the University of Toronto. Discussion presented in the report called, "Shear Behaviour of Concrete Box Culverts: A Preliminary Study" by R.A. Yee, E.C. Bentz, and M.P. Collins, identifies areas of weakness and lack of clarity in the current codes governing box culvert design.

The study developed an experimental procedure to determine the adequacy of the current shear design procedures for a range of commercial box culverts. By comparing the experimental results to the analytical predictions from the shear strength equations in North American codes, the ability of these provisions to predict the shear behavior of the test specimens was examined. Ultimately, the objective is to use the information to provide recommendations to industry outlining the adequacy of commercial box culvert designs in shear, and to more accurately identify where shear reinforcement is required and where it is not. The analytical and experimental results are useful to future box culvert studies and the precast industry, as well as to industry associations and academics involved in researching the shear behavior of concrete

structures.

In addition to the observations at Centennial, there were other reasons for investigating the adequacy of the current shear design procedures. In 2000, the Canadian Highway Bridge Design Code (CHBDC) was updated and became the principal culvert design guideline for Ontario, formerly under the jurisdiction of the Ontario Highway Bridge Design Code (OHBDC). This change in code prompted concern by the Ontario concrete pipe industry that products of some OCPA producers would no longer appear to be adequate in shear under the revised code provisions, even though no deficiency in shear behavior had been observed in the field.

Some uncertainty remains as to the precise load causing shear failure under ideal worst-case conditions due to the presence of axial load as a result of the test set-up conditions. Axial loads in the slab were several times those specified by design specifications but were necessary to ensure a statically determinate loading scheme. Most code predictions anticipate that the presence of these additional axial loads would enhance the shear capacity of the sections by 10 percent or less, with the exception of the method presented in CHBDC 7.8.8.2.1. The adoption of the expression

$$M_{nU} = M_U - N_U \frac{4h-d}{g} \text{ in CHBDC Clause 7.8.8.2.1}$$

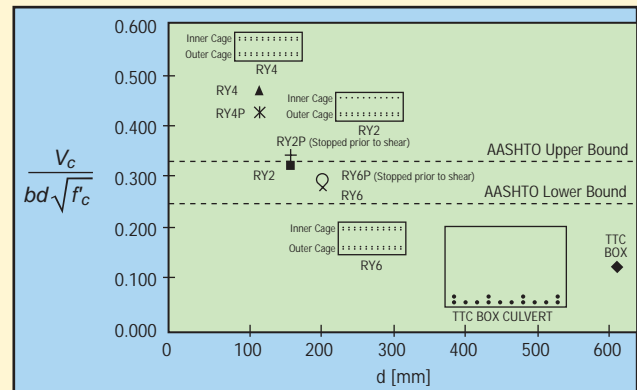
to account for axial load has a significant influence on shear strength predictions, increasing these predictions on average 1.5 times in this experimental program. This may lead to un-conservative predictions of shear strength if axial loads are significant.

Stirrups, which are commonly used in the reinforcing design of box units for shear design, were not used in any of the specimens cast for this testing.

The code shear provisions should be able to predict the behavior of the loaded culverts in the experiments regardless of the presence of axial load. All the code shear provisions were found to underestimate the shear capacity of the culvert members. Three shear code equations from CHBDC and the AASHTO box culvert shear equation were studied. Calculations were performed assuming an elastic member response. The test data confirmed that the point of inflection between the regions of the positive and nega-

tive moment in the slab shifts inwards toward the mid-span at higher loads. As an elastic analysis predicts a stationary inflection point, it was found that actual post-cracking moments in the sections of higher shear stress were lower. This would suggest that the use of elastic methods in design is somewhat conservative, and hence the code predictions should be slightly conservative. CHBDC code provisions predicted shear failures 56 percent of actual observed shear failures. The AASHTO Box equation was less conservative predicting shear failure on average 71 percent of actual observed shear failures. Care must be taken, however, to recognize the limitations of the AASHTO equation. Studies have shown that the shear capacity of a reinforced concrete member is subject to a size effect depending on the depth of the section. Shear critical sections tested in this study are plotted with a much larger box culvert section tested at the University of Toronto Structural Laboratories for the Toronto Transit Commission (TTC) in Figure 1.1. The

Figure 1.1: Size Effect

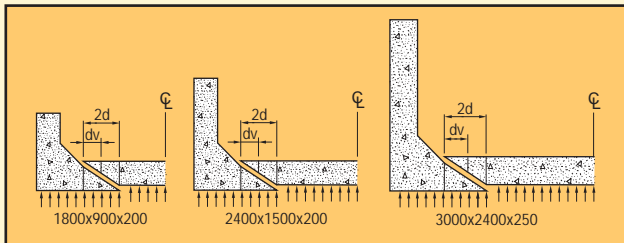


CHBDC General Method was found to give an accurate prediction of the failure load of the TTC box (Kuzmanovic 1998). Notice, however, that the empirical AASHTO minimum limit gave a highly un-conservative prediction of strength for the TTC box. Tests on larger depth members show that the AASHTO minimum limit can be dangerous for application to specimens with larger section depths due to the size effect in shear. Curiously, the lower limit on the AASHTO equations of $0.25\sqrt{f'_c}bd$ is the same as the upper limit on the CHBDC Clause 7.8.8.2.1. This could imply that CHBDC Clause 7.8.8.2.1 Method is limited by an overly conservative expression.

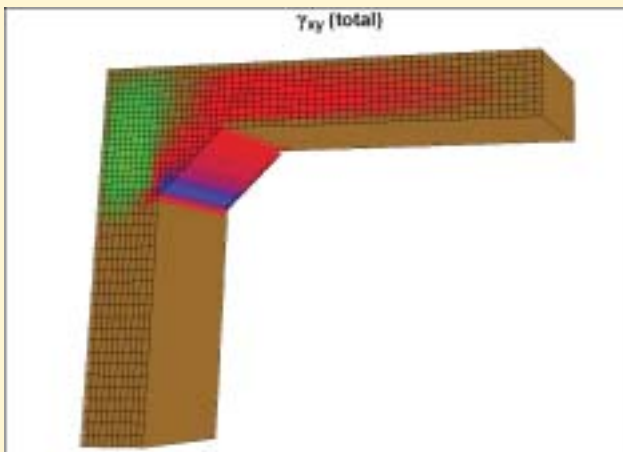
The CHBDC General Method gave the most

consistent predictions. Since the CHBDC General Method is known to give accurate predictions in other applications, clearly there are factors not being considered when applying it to culverts.

Figure 1.2: Specimens Considering Load Paths of Forces



One possible source of error could arise from an inappropriate consideration of the loaded length that influences the critical shear section. In Figure 1.2, the tested culvert sizes are shown to scale with the critical section at d_v from the haunch and crack extending to $2d$ from the haunch. When considering the load path of the applied load, it would be reasonable to assume that all of the load on the haunch side of the break would flow directly into the culvert wall. Thus, the actual load acting on the critical section at d_v could be less than anticipated, indicating that the section would fail at higher loads. Issues such as concrete cracking strength (which has a profound influence on the shear strength of sections without transverse shear reinforcement), the superior bond characteristics of the reinforcement mesh, and the previously mentioned conservatism associated with internal loads determined from elastic analysis results, may all contribute to the overall conservatism of the predictions.



Model shows strain when loaded. The darker the color, the greater the strain. Green is least and blue is greatest.

Although the study represents a preliminary investigation, there is substantial evidence included in the study report to suggest that shear reinforcement may have little influence in the design of most culvert sections conforming to Ontario Provincial Standards Specification (OPSS) 1821 – Material Specification for Precast Concrete Box Culverts and Box Sewers if concrete is allowed to reach sufficient compressive strength. Results also indicated that shear reinforcement for many deeper earth cover applications may not be required to satisfy the CHBDC design load requirement. The study recommends, however, that further testing confirm any such inference, particularly for box members with lower concrete strengths.

The preliminary investigation into shear behavior of concrete box culverts gave an indication of the design's susceptibility to shear failure in the box slab. The experimentation also clearly established the load range at which shear failure is to be expected in the slab, the reliability of analytical techniques at predicting member internal forces, and the conservatism of both the box member design and code shear prediction methods outlined in CHBDC and AASHTO codes. The findings provide a basis from which to expand the reliability and scope of the investigation so that specific recommendations can be made to codes reflecting the conservatism of the culvert designs. With a greater understanding of the behavior of the culverts in shear it would also be possible to expand the range of culvert sizes and design depths standardized in OPSS 1821.

The investigation into shear behavior of concrete box culverts continues. The Ontario Concrete Pipe Association is working with its industry partners including the American Concrete Pipe Association and Canadian Concrete Pipe Association to acquire funds required for the next level of research. When completed, the research is expected to have a significant impact on the cost of buried infrastructure and the use of resources for producing precast concrete boxes. But most significantly, the research will have a profound impact on design methodology and principles used in industry and academia for concrete structures that ensure public safety. ☺

Source: Yee, R.A., Bentz, E.C., Collins, M.P., *Shear Behaviour of Concrete Box Culverts: A Preliminary Study*, Department of Civil Engineering, University of Toronto, January 2004.

President's Message

continued from page 3

that performance, durability and quality are major ingredients in the recipe for sustainability. Over the past 15 years, environmental issues have come to play a major role in the choice of construction materials used for buried infrastructure, buildings and transportation facilities. Many municipalities, state governments and federal government agencies have drafted or adopted policy to embrace the principle of sustainability.

Because concrete is the most common building material in the world, requests for the environmental attributes and sustainability of concrete structures are increasing, as society faces the realities of sustainability. The concrete pipe industry is ready to respond.

The establishment of the Department of Homeland Security early in this decade underscores the vital need for infrastructure that can withstand the actions of terrorists and the rapid deployment of security forces, as well as sustaining the nation's commerce. Buried concrete pipelines and culverts are sustainable systems designed to meet the needs and aspirations of the current generation without compromising the ability to meet those of future generations – as called for by the United Nation's definition of sustainable development. As a sustainable product that carries the aspirations of the green movement, precast concrete pipe also falls well within the federal government's imperative to purchase green products. Precast concrete drainage products have a lesser or reduced effect on human health and the environment when compared to other products that serve the same purpose. This fact is laid bare by the many design tools, research and case histories in the concrete pipe industry that accommodate life cycle analysis and durability of buried concrete infrastructure.

What does the green movement mean to the concrete pipe industry? Not much, without an understanding that sustainable products are intrinsic elements of the green movement, and that the movement would not withstand the test of time without a well developed precast concrete delivery system. ☺

Close To Home

continued from page 8

Before construction could begin, Site Concrete crews had to install a cofferdam to hold back the waters of Lake Carolyn and dewater the construction site so that the 98-foot section of (10-foot x 10-foot) concrete box culvert could be installed and a new shoreline established. Once in place, the roadbed and associated utilities were constructed along the road right-of-way over the culvert.

The six-story parking garage adjacent to Fuller Drive provided an excellent perch for ACPA staff to observe site excavation as well as monitor pipe installation. It also provided a bird's-eye view of the scope of the project, and meticulous preparation and planning required during the fast-paced open cut installation. Daily and weekly observations created a new appreciation for the pre-planning that many members of the American Concrete Pipe Association undertake to ensure that proper product is delivered in the correct sequence for storing on the job site, so that the contractor has quick and easy access to products when ready for installation.

From its beginning, the model city has attracted offices of high profile corporations, educational, recreational and commercial enterprises. The vision is long-term for Las Colinas and it is designed on principles of a sustainable development marked by an energy-efficient urban design of housing, workplace environments, recreational opportunities and buried infrastructure lifelines made of precast reinforced concrete drainage products. Las Colinas is an example of smart development where concrete products have been wisely applied recognizing that long-term performance and durability are essential elements of twenty-first century urban design. ☺

Institute of Religion Campus

continued from page 10

The use of precast concrete box sections for underground stormwater detention and treatment systems is growing throughout North America. Precast concrete products are designed with performance and durability in mind to meet the nation's commitment to sustainable development. The stormwater infrastructure system of the Salt Lake University Institute of Religion building promises to endure as long as the campus itself. ☺

Joe Burnham founded Geneva Pipe in 1956 on the 13-acre Orem, Utah plant site.

In 1960, Burnham partnered with Aldo Bussio, owner of the trucking enterprise that delivered his products, and in 1990, Bussio was elected Chairman of the American Concrete Pipe Association. Today, Geneva Pipe is now one of the nation's key concrete pipe producers with plants in Orem Utah (corporate), Moapa Nevada, and Hurricane Utah. See www.geneva-pipe.com for product and project details.

"Quality Cast" Certified Plants

To improve the overall quality of all concrete pipe products, the American Concrete Pipe Association offers an on-going quality assurance program to member and non-member companies. Called the "Quality Cast" Plant Certification Program, the 124-point audit-inspection program covers the inspection of materials, finished products and handling/storage procedures, as well as performance testing and quality control documentation. Plants are certified to provide storm sewer and culvert pipe or under a combined sanitary sewer, storm sewer and culvert pipe program. The following plants are currently certified under ACPA's Quality Cast Certification Program:

Storm Sewer and Culvert Pipe

- Atlantic Concrete Pipe, San Juan, PR - Miguel Ruiz
- Boughton's Precast, Inc., Pueblo, CO - Rodney Boughton
- California Concrete Pipe (Oldcastle), Stockton, CA - Qing Lian Gao
- Carder Concrete Products, Littleton, CO - Bruce Spatz
- Carder Concrete Products, Colorado Springs, CO - Tom Walters
- Cayuga Concrete Pipe Company (Oldcastle, Inc.), Croydon, PA - Allen Reed
- Cayuga Concrete Pipe Company (Oldcastle, Inc.), Montrose, PA - Joe Diana
- Cayuga Concrete Pipe Company (Oldcastle, Inc.), New Britain, PA - Kim Venable
- Elk River Concrete Products (Cretex), Billings, MT - Milton Tollefsrud
- Grand Junction Concrete, Grand Junction, CO - Ben Burton
- Kerr Concrete Pipe Company (Oldcastle, Inc.), Hammonton, NJ - Bob Berger
- Kerr Concrete Pipe Company (Oldcastle, Inc.), Farmingdale, NJ - Scott McVicker
- NC Products (Oldcastle, Inc.), Raleigh, NC - Mark Sawyer
- Oldcastle Precast, Inc., Lebanon, TN - Jeff Masters
- Permatile Concrete Products, Bristol, VA - Charles Rainero
- Rinker Materials-Hydro Conduit, Denver, CO - Mike Leathers
- Rinker Materials-Hydro Conduit, Oakdale, PA - Ken Souffrant
- Riverton Concrete Products Company (Cretex), Riverton, WY - Butch Miller
- Sherman-Dixie Concrete Industries, Inc., Chattanooga, TN - Chris Mears
- Sherman-Dixie Concrete Industries, Inc., Franklin, TN - Tony Jackson
- Sherman-Dixie Concrete Industries, Inc., Lexington, KY - Darrel Boone
- Sherman Industries, Huntsville, AL - Billy Fagan
- South Dakota Concrete Products (Cretex), Rapid City, SD - Jeff Ullrich
- South Dakota Concrete Products (Cretex), Mitchell, SD - Andy Fuhrman

Sanitary Sewer, Storm Sewer and Culvert Pipe

- Amcor Precast (Oldcastle, Inc.), Nampa, ID - Mike Burke
- Amcor Precast (Oldcastle, Inc.), Ogden, UT (12th Street) - Bob Jolley
- Amcor Precast (Oldcastle, Inc.), Ogden, UT (Wall Avenue) - J. P. Connoley
- Elk River Concrete Products (Cretex), Elk River, MN - Bryan Olson
- Elk River Concrete Products (Cretex), Shakopee, MN - Steve Forslund
- Geneva Pipe Company, Orem, UT - Fred Klug
- Kansas City Concrete Pipe Co. (Cretex), Shawnee, KS - Lynn Schuler
- Langley Concrete & Tile, Ltd., Langley, BC (Canada) - Mark Omelianiec
- NC Products (Oldcastle, Inc.), Fayetteville, NC - Preston McIntosh
- Ocean Construction Supplies Limited (Inland Pipe), Vancouver, BC (Canada) - Ron Boyes
- Waukesha Concrete Products Company (Cretex), Waukesha, WI - Jay Rhyner

Box Culvert

- Carder Concrete Products, Littleton, CO - Bruce Spatz
- Grand Junction Concrete, Grand Junction, CO - Ben Burton
- Langley Concrete & Tile, Ltd., Langley, BC (Canada) - Mark Omelianiec
- Sherman-Dixie Concrete Industries, Inc., Franklin, TN - Tony Jackson
- South Dakota Concrete Products (Cretex), Rapid City, SD - Jeff Ullrich
- South Dakota Concrete Products (Cretex), Mitchell, SD - Andy Fuhrman



PIPEPAC UPGRADE IMPROVES EASE OF USE AND APPLICATIONS

North American designers and specifiers of buried drainage infrastructure have been using PipePac software for more than six years. PipePac is a program that offers an integrated analysis using independent programs for D-load calculations (3EB), estimating the material costs of the pipe embedment zones (CAPE), and calculating the real cost of the materials specified over the design life of the project (LCA).

Users can select either metric or imperial units for calculations and results, with defaults to common specifications in both the United States and Canada. The program is versatile and user-friendly in a Windows-based environment.

Version 3.0 is now available. The new edition has a Microsoft XP platform option. In addition, it has an Access 2002 database, the Canadian Highway Bridge Design Code, CAN/CSA-S6-00 revisions, pipe cost tables in CAPE, easy printing options in CAPE, no costing when no bedding design has been selected, and more comprehensive help files.

PipePac was developed by, and continues to be upgraded by the concrete pipe industry in the U.S.A. and Canada. The program is a cooperative effort between the American Concrete Pipe Association, Canadian Concrete Pipe Association, Ontario Concrete Pipe Association, Tubécon (Québec-based concrete pipe association) and Giffels Associates Limited (software engineers). The Cement Association of Canada also provided funds for the latest upgrade.



Over 12,000 copies of PipePac have been distributed and downloaded by engineers, educators, government officials, contractors and consultants. You can download Version 3.0 at www.concrete-pipe.org, or obtain a CD-ROM through members of the support concrete pipe associations. You may also order a copy

of the program from ACPA's Resource Center by calling 1-800-290-2272. Cost: \$10.00 member/\$20.00 non-member, plus shipping and handling. Company check, VISA, MasterCard, and American Express are accepted.☺



American **Concrete Pipe** Association
222 W. Las Colinas Blvd., Suite 641
Irving, TX 75039-5423

www.concrete-pipe.org

PRESORTED
STANDARD
US POSTAGE PAID
DALLAS, TX
PERMIT NO 1883