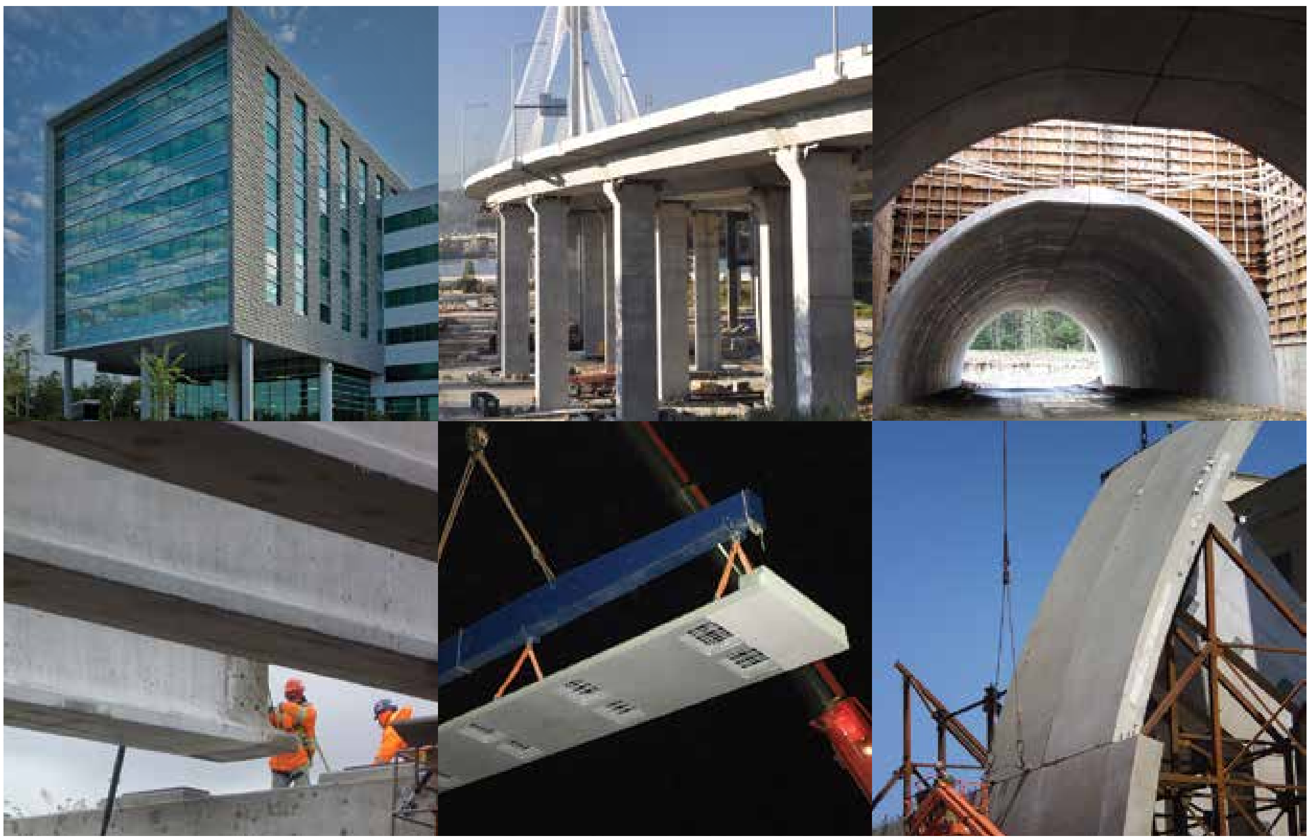
DESIGNING WITH PRECAST CONCRETE

Infrastructure Solutions



TECHNICAL GUIDE

CPCI.ca Precast Concrete... Sustainable Structures for Tomorrow!

Canadian Precast/Prestressed Concrete Institute

Precast Concrete...
Sustainable Structures for Tomorrow!

Canadian Precast/Prestressed Concrete Institute
PO Box 24058 Hazeldean
Ottawa, Ontario
Canada
K2M 2C3

Telephone (613) 232-2619 Fax: (613) 232-5139

Toll Free: 1-877-YES-CPCI (1-877-937-2724)

E-mail: info@cpci.ca

www.cpci.ca

For More Information: *CPCI Design Manual,* Latest Edition order from: www.cpci.ca

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Infrastructure For Life

When we think of infrastructure we think not only of built infrastructure such as roads, but also bridges, drinking water, wastewater and storm water systems, and social infrastructure such as schools, hospitals and libraries.

It is well understood that the country's infrastructure is aging. Much of the highway and water and sewer systems was built in the 1950s and 1960s, arriving at an important stage of their service lives. Depending on materials used, some have already failed or are in great need of rehabilitation or replacement. Traffic demand has grown tremendously without a corresponding increase in highway capacity, resulting in an increasingly high level of congestion. Large building construction projects simply compound traffic problems during lengthy construction periods. The traveling public demands high quality, longer-lasting highways, bridges and structures but they want any construction-related activity completed quickly and economically. In order to address this problem, public and private authorities need to adopt a new philosophy of "Get in Get out–Stay out."

Regulatory authorities are realizing that high quality precast concrete components, from certified precast facilities, can be used to minimize interference to the public during construction projects. The use of precast concrete components for many new or replacement bridge and/or water and sewer projects, have demonstrated significant reductions in construction time, reduced impacts on traffic flow and the environment, as well as long life performance.

Structural & Architectural Precast Prestressed Concrete

Few building materials available today offer the economy, flexibility and reliability of precast prestressed concrete. Precast infrastructure components include elements such as: beams, I-girders, bulb Tees, Double Tees, stemmed members, box girders, solid slabs, full or partial depth bridge deck slabs, tunneling components, conventional and integrally insulated wall panels, hollowcore slabs, stairs, seating members, railroad ties, piling, sheet piling, piling caps, retaining wall elements, median barriers, parapet walls, sound barriers, vaults, box culverts, pipe and manholes. The scope of applications is unlimited.

Long Lasting

Precast concrete infrastructure components provide durable construction, especially when precast prestressed concrete components are used. A continuous evolution of new material technologies has enabled concrete with enhanced resistance to corrosion, chlorides, fire, weather extremes, chemical attack, accidental damage and the determined efforts of vandals. Precast prestressed concrete will provide reliable durable, long-term performance in extremely harsh conditions that can otherwise destroy other materials.

Plant-cast precast concrete allows CPCI members to exercise precise control over concrete materials, placement of reinforcement, and control of curing to positively affect durability, strength and appearance. Dense impermeable concrete is readily produced. Plant cured precast concrete structural components are delivered to the site with the majority of the drying shrinkage having already taken place. This reduces the potential for cracking and future maintenance costs. All CPCI member plants manufacture in accordance with CSA standard A23.4 "Precast Concrete—Materials and Construction".

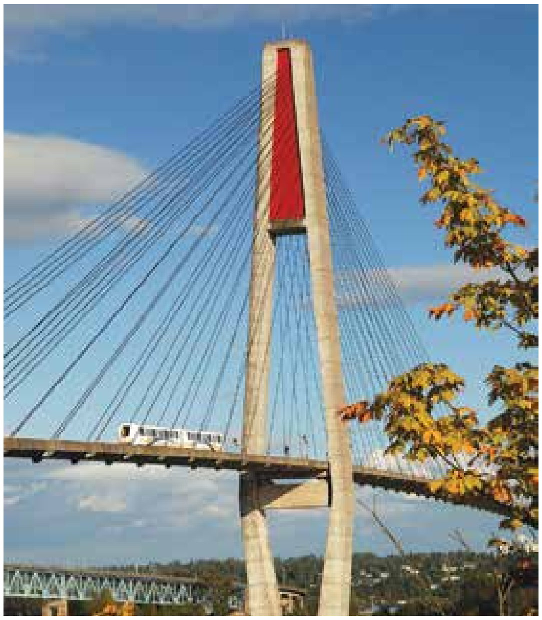
Structural precast is certified by CPCI to CSA Standard A23.4—Precast Concrete Materials and Construction, and the United States requirements according to PCI MNL-116. CPCI Certification is the most stringent certification for precast concrete products in Canada. More information can be found at **www.precastcertificaton.ca**.

Fast Construction

Infrastructure projects must be built expeditiously in order to reduce the impact on the public. Precast concrete components achieve this goal with plant fabrication proceeding while site preparations are underway. The ability to cast and erect precast components, even in inclement winter weather, minimizes costly weather delays. Fast construction means earlier completion and results in significant cost savings.

Innovation

Precast concrete infrastructure components use technologies that impact aesthetics, durability, initial and long-term costs, speed of construction, efficiency and safety. Bridges utilizing integral full or partial depth precast concrete decks achieve high span-to-depth ratios, creating slender, aesthetically pleasing structures with increased clearances.



Expanded use of coloured concretes, textures and finishes allow precast infrastructure projects to blend in with the local environment, including replacement and rehabilitation of historically significant projects. Total precast concrete systems are being used more frequently. These systems offer unmatched speed of construction, single source responsibility and the just-in-time delivery of components.

Self-consolidating concrete (SCC) is an everyday option in many infrastructure applications. Increases in workability and fluidity improve the final appearance of the components, create higher density concrete and allow the creation of more complex shapes. Carbon and Glass Fiber Reinforced Polymer reinforcing (CFRP and GFRP) offer even higher strength-to-weight ratios and higher resistance to corrosion. Spliced girder technology allows infrastructure components with spans that are continually being extended. Projects are now being designed with spans as long as 100 m. Additional approaches, such as cantilever designs and higher strength concrete, can further extend these spans. The value-engineering of infrastructure designs using precast concrete options can save significant construction time, money and reduce environmental impact.

Economy

Standard structural shapes such as hollow core, double tees, beams, girders, columns and panels can be mass-produced at low cost.

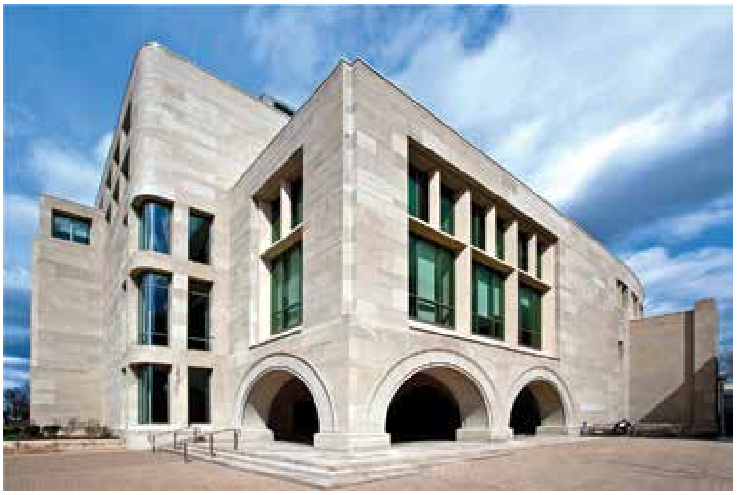
Where custom-engineered products are desired, careful design work can assure maximum economies of scale through repetitious casting.

Beauty

Precast components can be delivered with a wide range of shapes and finishes ranging from smooth dense structural units to any number of architectural treatments.

Strikingly rich and varied surface textures and treatments can be achieved with coloured sands, aggregates, cements and colouring agents and through exposing by sandblasting and chemical retarders.

Custom forms and formliners can be used to introduce reveals, patterns and other architectural effects that are not possible with other materials. Stone, tile brick and other materials can be cast into precast panels at the precast plant, enabling designers to achieve the expensive look of stone masonry at a fraction of the price.



More information can be found in the CPCI *Architectural Precast Concrete Technical Guide* at **http://tinyurl.com/mumektt** .

Infrastructure Distress

In 2012 Canada's first national report card on the state of municipal infrastructure was published by the Canadian Construction Association (CCA), Canadian Public Works Association (CPWA), Canadian Society for Civil Engineering (CSCE), and the Federation of Canadian Municipalities (FCM). The study provides an assessment of the condition of four primary asset categories of municipal infrastructure: drinking-water systems, wastewater and stormwater networks, and municipal roads. This is the first assessment of its kind in Canada, and features the most comprehensive analysis and reporting to date on Canada's municipal infrastructure. **http://www.canadainfrastructure.ca/**. The study highlights the importance of infrastructure management and the need to consider solutions today that are founded on the principles of durability, resilience and lifecycle costing. Highlights included:

Wastewater infrastructure

- 40.3% of plants, pumping stations and storage tanks were in fair to very poor condition
- 30.1% of pipes were in fair to very poor condition
- Replacement cost: $39 billion

Drinking water infrastructure

- 15.4% of drinking water pipes were in fair to poor for the condition
- Replacement cost: $ 25.9 billion

Stormwater management

- 12.5% of the stormwater installations surveyed fall below good condition
- 23.4% of the stormwater pipes fall below good condition
- Replacement cost: $15.8 billion

At the time of this study*, the total replacement cost to upgrade all of these linear assets was 80.7 billion or $6,488 per Canadian household.

Reports such as these emphasize the need to re-examine what materials and procurement processes we use to construct or rehabilitate our infrastructure. When considering longevity and life cycle cost, all infrastructure product materials are not created equal.

Certified precast concrete elements manufactured in CPCI member plants are capable of providing long lasting solutions for infrastructure construction. Precast prestressed concrete can be deployed in infrastructure applications to achieve:

1. corrosion mitigation,
2. reinforcement of degraded bridge components,
3. seismic protection,
4. low-cost erection / low-cost maintenance, and
5. minimal disruption to the public during construction

CPCI members work closely with cities, municipalities, provincial departments of transportation, and engineering consultants to:

6. understand their needs and requirements,
7. provide education on the technology and uses of precast concrete materials, components, systems and structures,
8. assist in finding long-lasting, economical precast prestressed concrete solutions, and
9. encourage innovative uses of precast concrete components for both new and rehabilitating existing structures.

*For this study, the following rating definitions applied:
Very good: Fit for the future **Good:** Adequate for now **Fair:** Requires attention **Poor**: At risk
Very poor: Unfit for sustained service Visit **http://tinyurl.com/koq98xf** to download this study.

Corrosion Protection

Protection of reinforcing steel from corrosion can be achieved by proper concrete cover. Concrete with sufficiently low permeability and adequate cover will protect the reinforcement. Additional protection methods can be used if desired:

- prestressing (to eliminate or reduce cracking).
- steel reinforcement coatings—galvanized and epoxy coated
- Corrosion resistant reinforcing—various grades of stainless steel, glass and carbon fiber bars
- corrosion inhibiting concrete admixtures
- distributed fiber reinforcement in the concrete matrix

For a more detailed discussion of this topic, see the *CPCI Design Manual* (Latest Edition) and the PCI *Architectural Precast Concrete Manual*, Third Edition.

High Performance Concrete (HPC)

"High performance concrete (HPC) is defined as concrete which meets special performance and uniformity requirements that cannot always be achieved using only the conventional materials and mixing, placing and curing practices. The performance requirements may involve enhancements of placement and compaction without segregation, long-term mechanical properties, early age strength, toughness, volume stability, or increased service life in severe environments."—ACI 2013.

Many infrastructure owners are demanding an extended service life and want reassurance prior to construction that it will be achieved. It is widely accepted that life-cycle costs for HPC structures will be lower than those of similar structures using conventional concrete. First costs for HPC may seem higher, but this is overcome by a structural design that utilizes the structural benefits of higher strength concrete. Bridges and other structures can now be specified for a designed service life in excess of 100 years.

The impermeability of concrete cover is paramount and should be the first line of defense against the deterioration processes that our infrastructure is subjected to. Prestressing enhances durability by placing the concrete in compression and eliminating most cracking at service loading conditions. Precast elements are cast in facilities under highly controlled conditions.

Production and quality control are both carefully supervised. Products and processes are monitored and certified through the CPCI Certification Program. The concrete and the cover to the reinforcement are carefully controlled. The controlled curing of concrete in a precast plant can have a significant positive impact on the subsequent durability of the concrete.

CSA A23.1 "Concrete Materials and Methods of Concrete Construction" specifies the ASTM C1202-12 "Test Method for Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration", commonly called the Rapid Chloride Permeability (RCP) test as a measure of concrete permeability. Maximum coulomb ratings at 56 days are specified and verified by the test. For C-XL concretes the requirement is maximum 1000 coulombs and for C-1 concrete the requirement is maximum 1500 coulombs.

A state of the art report conducted by the National Research Council (NRC) on behalf of CPCI (2014) demonstrates that these coulomb ratings, along with the required 56 day strengths, can be met at CPCI certified precast facilities with 16 hour accelerated curing followed by air curing.
http://www.cpci.ca/en/resources/technical_publications/

Concrete Materials & Design Standards

CSA Standard A23.1 – Concrete Materials and Methods of Concrete Construction

CSA Standard A23.2 – Methods of Test for Concrete

These standards are referenced in the National Building Code and give the technical requirements for cast–in–place concrete. Test methods for predicting performance and evaluating minimum levels of quality are given in CSA A23.2.

CSA Standard A23.3 – Design of Concrete Structures

This standard covers the design requirements for most concrete structures (except bridges). Clause 16 Precast Concrete covers the design requirements for precast concrete. An improved concrete material resistance factor is allowed for certified precast concrete structural members. Clause 18 Prestressed Concrete covers the design requirements for pretensioned and post–tensioned concrete.

CSA Standard A23.4 – Precast Concrete – Materials and Construction

A23.4 covers the technical requirements for precast concrete. In most cases, the requirements are higher than cast–in–place concrete because of the closer control possible in a precast plant.

CSA Standard S6 – Canadian Highway Bridge Design Code

This Code applies to the design, evaluation, and structural rehabilitation design of fixed and movable highway bridges in Canada. This Code also covers the design of pedestrian bridges, retaining walls, barriers, and highway accessory supports of a structural nature, e.g., lighting poles and sign support structures.

CSA Standard S6.1 – Commentary on the Canadian Highway Bridge Design Code

This standard covers the design of highway bridges. Clause 8 covers Concrete Structures and Clause 8.7 covers Prestressing Requirements. Other specific requirements for precast concrete bridge construction are outlined in Clause 8.

CSA Standard S413 – Parking Structures – Structures Design

Many parking structures are unheated and subject to short and long–term temperature variations that can be large. Most parking garages are also exposed to the corrosive effects of deicing (road) salt. The quality of precast construction and the beneficial effects of prestressing are recognized in this standard.

CSA Standard S806 – Design and Construction of Building Components with Fibre Reinforced Polymers

Canada is the first country with a building code for FRP. FRP are also recognized in CSA Standard S6 – CHBDC.

The latest editions of these CSA publications are available for online ordering from the Canadian Standards Association website at: **http://shop.csa.ca/**

Guide Specifications

SPECIFICATION – Section 03450 – Architectural Precast Concrete

SPECIFICATION – Section 03410 – Structural Precast/Prestressed Concrete

SPECIFICATION – Section 034113 – Hollow Core Precast/Prestressed Concrete

These updated guide specifications are available for downloading at the CPCI website: **www.cpci.ca**

Precast Concrete–An Intelligent Material for Resilient Infrastructure Construction

Disaster resilience is everyone's business and is a shared responsibility among citizens, the private sector, and government. Increasing resilience to disasters requires bold decisions and actions that may pit short-term interests against longer-term goals. As a nation we have two choices; We can maintain the status quo and move along as we have for decades, or we can begin by addressing important, immediate issues through such measures as **Canada's National Disaster Mitigation Strategy**, launched in 2008 (**the goal of the National Disaster Mitigation Strategy is: *To protect lives and maintain resilient, sustainable communities by fostering disaster risk reduction as a way of life***).

Such a path requires a commitment to a new vision that includes shared responsibility for resilience and one that puts resilience and resilient structures in the forefront of many of our public policies that have both direct and indirect effects on enhancing resilience.

While few would argue with the need to enhance the resilience of the nation's infrastructure, structures and our communities to natural hazards, conflicts arise in how to move towards enhancing resilience, how to manage the costs of doing so, and how to assess its effectiveness. The costs of disasters are increasing as a function of more people and structures in harm's way as well as the effects of the extreme events themselves. These costs are being incurred at a time when more and more communities are financially constrained and unable to pay for essential services such as public safety and education. The choices that local communities have to make are thus difficult and not without some pain. At the same time, federal, provincial and local governments have their own sets of constraints in terms of budget priorities, national interests, aging and declining infrastructure, and the political realities of implementing the kinds of changes needed to increase resilience within our communities.

Critical facilities commonly include all public and private facilities that a community considers essential for the delivery of vital services and for the protection of the community. They usually include emergency response facilities (fire stations, police stations, rescue squads, and emergency operation centers [EOCs]), (long-term care facilities, hospitals, and other health care facilities), schools, emergency shelters, utilities (water supply, wastewater treatment facilities, and power), communications facilities, and any other assets determined by the community to be of critical importance for the protection of the health and safety of the population. The adverse effects of damaged critical facilities can extend far beyond direct physical damage. Disruption of health care, fire, and police services can impair search and rescue, emergency medical care, and even access to damaged areas.

Fire resistant precast concrete building components make them the ideal non-combustible building material. Fire ratings of one to four hours are available. Precast doesn't burn. It doesn't give off smoke or toxic fumes when exposed to fire. Concrete doesn't fuel the fire. Concrete maintains its structural integrity and can be designed for effective containment of fires, keeping fires from spreading to other parts of a building. This results in more time to evacuate safely and extinguish the fire and little chance of injury or damage outside of the area where the fire started. This means savings in insurance and liability costs. The public is better protected in the event of an emergency. Total destruction of wood frame residential buildings (both under construction and in service) has become an increasing concern with respect to public safety and inconvenience over the past decade. This type of destruction is virtually unheard of with concrete construction.

Precast concrete walls and structural precast floors and roofs are impermeable to damage by termites and other pests, they control exterior and interior noise, control vibration and damage due to mould, humidity, corrosive materials and direct impact.

Design requirements for large, open areas such as libraries, gymnasiums, field houses, auditoriums and cafeterias can easily be met by precast prestressed structural systems. Slender, long spans, capable of carrying heavy loads, result in reduced building height. Precast concrete wall panels can be designed as load bearing—removing the need for interior framing. Precast structural systems can minimize the risk of corrosion from humidity and chemicals.

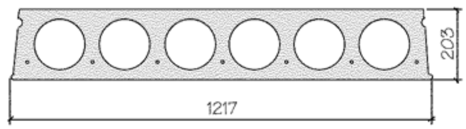
Taxpayers rely on administrators and designers to provide maximum value when building new and expanded facilities. Construction deadlines, manageable budgets, highly functional facilities and low maintenance are all critical concerns when planning new public projects.

Structural & Architectural Precast Concrete Systems

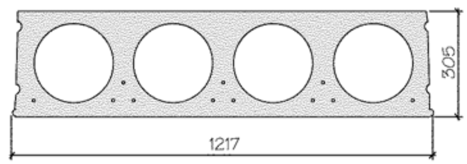
No other building material can match the long-term durability, low-maintenance and cost-reduction qualities of precast concrete. Many structures require large, unobstructed open plans for flexible space planning. Precast offers flexible building systems that encourage and enhance new approaches to meet the changing needs of modern buildings. Precast is cost-competitive, consistently high quality and offers more flexibility than most other structural and cladding materials. A complete review of structural precast solutions using precast concrete can be found at **http://tinyurl.com/lyd4wxv**.

Hollow Core Slabs

Hollow core slabs are constructed using low-slump concrete and high strength prestressing strands. Continuous voids are formed through each unit to reduce weight and improve structural performance. Slabs are available in 203 mm (8 in.), 254 mm (10 in.), 305 mm (12 in.) and 356 mm (14 in.) depths, with spans ranging up to 15.5 m (to over 50 ft). Contact your local CPCI member for specific sizes, span/loading and detailing information.



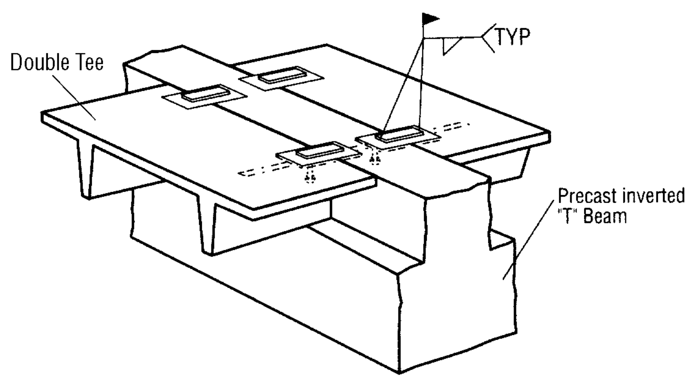
203mm slab

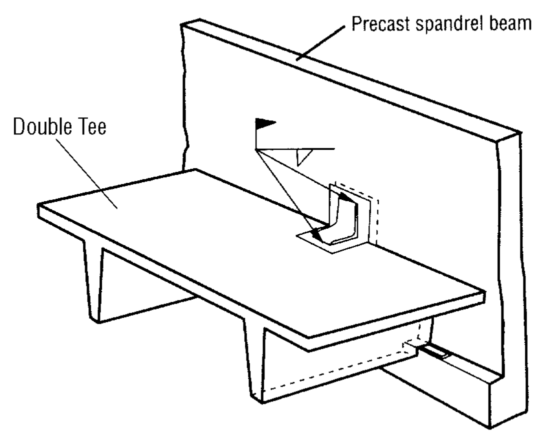


305mm slab

Precast Prestressed Double Tees

For spans and loads that exceed the capacity of hollow core slabs, double tees are an economical option. Double tees range from 1220 mm (4 ft. 0 in.) widths to 3000 mm (10 ft. 0 in.) and 3660 mm (12 ft. 0 in.) or more. Depths can vary from 300 mm (1 ft.) to 1000 mm (3 ft.). Spans can range from 10 to 25 m for floor loadings to over 33 m (33, 82 and 108 ft.) for roofs. Double tee dimensions are based on many factors including structural efficiency, fire rating requirements, parking modularity, and design loading. Contact your local CPCI member for specific sizes, span/loading and detailing information.





Precast Framing Systems

Precast beam and column framing systems provide incredible flexibility in layout. Frames can be massive and strong or light and delicate. Most CPCI structural precast producers have standard shapes and sizes for columns, beams, walls and stairs. Ideally, the building design should take advantage of repetition and modularity of standard precast member sizes. However, precast components can also be modified and customized to suit specific project requirements. Prestressing beams will reduce construction depth and allow longer clear spans. Lateral forces can be resisted by cantilevered columns, diagonal bracing, shear walls, frame action or a combination of methods. Contact your local CPCI member for specific sizes, span/loading and detailing information.

Precast Concrete Wall Systems

Precast concrete insulated sandwich wall panels are economical and will enclose a building faster than comparable structural systems. Typically, the use of precast results in a reduction to the overall project schedule. Panels are available in a wide range of custom and standard widths, lengths, thicknesses, R-values and exterior finishes. Contact your local CPCI member for specific sizes, span/loading and detailing information.

The true benefit of architectural precast concrete is found in the virtually limitless aesthetic effects that can be achieved from its use. Custom forms are used to create precast panels in the exact size and shape using reveals, patterns, shapes and other architectural detailing specified by the designer. Colour effects can be achieved using various coloured sands, aggregates, cements, pigments and site applied penetrating stains. Textures can be customized with the use of retarders, acid washes and sandblasting. Custom shapes, patterns and unique features can be created with the use of standard or custom "formliners". Contact your local CPCI member for recommended panel sizes, design and detailing information.

Fast Construction

Shorter construction timetables and the ability to more accurately pinpoint completion and occupation dates are critical in planning new facilities. Precast construction is more predictable. Extremely short schedules are possible as precast components are factory constructed in CPCI member certified plants. Precast erection can proceed on a steady schedule year round in any weather. Precast components are delivered to the work site ready to install directly from the truck. In addition, precast decks provide an immediate work platform so other trades can start sooner.

Parking Garages

Parking structures often represent the first and last impression a visitor has when visiting an airport, hospital, public building or recreation centre. Excellent parking structures are designed specifically for the types of visitors a structure will serve, based on the facilities they support and the daily or peak flows of traffic. Unless a parkade is safe, secure and easy-to-use, drivers will find other options. Creating the best parking structure to fit a site, the users and budget requires a careful balance of all elements and a logical plan from start to finish. The early involvement of your local CPCI member while key design decisions are being made can make a dramatic difference to the final result. Their expertise and input can minimize the time and cost required to complete a project. Precast parkades offer fast construction, versatility of design, long column free spans, attractive exterior finishes, durability and economy; making precast prestressed concrete a popular choice for commercial, municipal and institutional clients.

Loads and Forces

Precast concrete parking structures allow for volume changes from creep, shrinkage and temperature differences. Components are cured before they are delivered to the site. The connections between members allow the structure to relieve pressures from ordinary expansion and contraction that otherwise could cause cracking in structural elements. Lateral design loads for wind, earthquake or earth pressures (for in-ground or partially buried structures) can be resisted in a precast concrete structure by transferring loads through the floor diaphragm to shear walls and/or to column beam frames. Care in locating shear walls, the adequate isolation of shear walls and the introduction of adequate isolation and expansion joints will assure satisfactory performance.

Loading walls with framing beams or floor members can minimize connections between shear walls to resist uplift forces. The torsion resistance of eccentrically loaded beams and spandrel panels must be considered. Connections can be designed to prevent beam rotation and absorb bumper loads (if applicable) without undue restraint against volume changes.

Bay Sizes

For maximum economy, bay sizes should be as large as possible and modular with the standard precast concrete floor elements selected. For clear span parking, the bay size selected need not be a multiple of the width of the parking stall.

Drainage

Sloping the structure to achieve good drainage is essential to quickly remove rain and salt laden water from the structure. The drainage pattern selected should repeat for all floors to allow for repetition in manufacturing the precast elements. Locate isolation (expansion) joints at high points to minimize possible leakage. Slope the floors away from columns, walls and spandrels where standing water and leakage could cause corrosion.

Durability

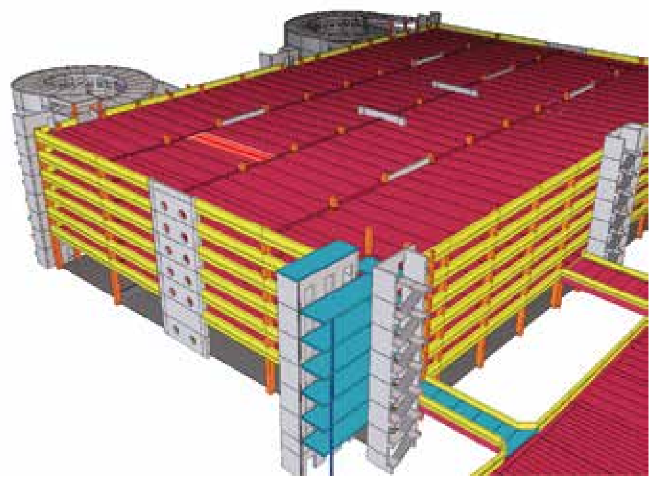
High strength factory produced precast reinforced and pretensioned concrete components have been found to be highly resistant to attack by chlorides.

There are two main precast floor systems used in Canada currently:

Cast-in-place concrete topping over thin flange precast double tees.

Where cast-in-place composite topping is used over precast floor members, wire mesh reinforcement should be incorporated in the topping. Good results have been achieved by providing a high strength concrete topping having a water cement ratio of 0.40 or less.

Concrete topping containing 6% entrained air and curing under wet burlap will produce the best results.



Pretopped thick flange precast double tee

Pretopped double tees are a recommended alternative to field-placed concrete toppings. An advantage of this system is that it produces an excellent 35 to 55 MPa plant produced wearing surface—instead of a lower strength field placed concrete topping. The top surface is typically broom-finished to provide improved driving traction. Special considerations are critical for adjacent camber differential, joint treatments, erection stability and drainage with this system. CSA Standard S413 specifies requirements for low-permeability concrete, acceptable protection systems and concrete cover for reinforcement and prestressing tendons.

Stadiums & Arenas

Large stadiums and arenas are impressive structures. Often these projects are built on tight budgets and schedules to accommodate important sporting events. Precast prestressed concrete has been the overwhelming choice for many of these projects.

Mass produced seating units are manufactured in a variety of configurations and spans to provide for quick installation and long lasting service. Pedestrian ramps, concession, washroom, and dressing room areas can all be framed and constructed using precast prestressed concrete elements.

The technique of post-tensioning precast segments together has allowed precast concrete elements to form complex cantilever arm and ring beam construction to support the roofs of some of these structures. Post-tensioning can be employed to reinforce precast concrete cantilevered raker beams, which carry the seating and provide unobstructed viewing of the playing surface.

Railway, Light Rail & Transit Structures/Facilities

Precast prestressed concrete has become the structural and architectural system of choice for a variety of transit facilities. Uses range from rail ties, canopies, station platforms, curbs and gutters, to the on-site parking structures.

Acting as social hubs for thousands of daily commuters, LRT's are often designed with unique architectural treatments. No single construction material lends itself to a more dazzling array of architectural treatments than precast prestressed concrete. Rich aggregates, decorative shapes, reveals and attractive stone and masonry veneers can all be employed to express a wealth of architectural detail.

In addition to these architectural requirements, transit facilities undergo a tremendous amount of cyclic loading conditions. Quality precast concrete, produced and erected under stringent quality controls meet these demands. Precast also effectively resists corrosion and damage from de-icing chemicals used at these facilities, while at the same time retaining its architectural appeal for years with no significant staining, discolouration or surface decay. Required maintenance is low—saving long-term costs as well as minimizing shutdown delays over the life of these facilities.

Privacy & Protection

Sound Walls and Fences

Sound barriers, positioned along the edges of major roads and highways, can reduce the transmission of direct sound to residential areas. Barriers should be as close to the sound source as possible and block the direct path of the sound. Sound reaching a residential area will be limited mainly by diffraction over the top of the wall when there are no significant sound leaks and the wall has a mass exceeding 20 kg/m^2. Having a sound-absorbing surface on the side of the barrier that faces the traffic will increase the sound attenuation.

Precast concrete sound walls have many advantages over wood, masonry and metal paneling. Precast concrete walls and pilasters can be manufactured in a wide variety of finishes, textures, patterns and colours. Panels can be finished on both sides to present a finished appearance to the roadway and the protected properties behind. Precast sound walls can be installed quickly in any weather. Precast concrete contributes toward sustainable construction and does not involve cutting down trees or the use of toxic wood preservatives. Precast sound walls are manufactured locally. They have excellent resistance to wind, seismic, snow plows and vehicle impacts. Precast sound walls resist corrosion and vandalism and can be sealed to ease the removal of graffiti.

Retaining Walls

Retaining walls provide lateral support to vertical slopes of soil. Retaining walls can be constructed of many different precast materials and with a variety of building techniques. Retaining wall design and wall type selection are driven by several factors; cost, required wall height, ease and speed of construction, ground water conditions and soil characteristics as well as building codes, site accessibility and aesthetics.

Designing a retaining wall requires knowledge of lateral earth pressure. It is possible to engineer an attractive long-lasting, precast concrete retaining wall structure that will meet all foreseen environmental, structural and construction demands.

Several soil parameters must be determined before an engineer can assess a particular wall design and its overall stability:

- soil unit weight
- angle of internal friction of the soil
- cohesion and plasticity indices for cohesive soils (for instance, clays)
- water table location.

Once the lateral earth pressures are known, a wall can be checked for stability. This includes checks for wall overturning, base sliding, and soil bearing capacity failures.

Mechanically stabilized earth (MSE) retaining walls consist of a facing system and a lateral tieback system. The facing systems usually consist of modular concrete panels with lateral restraining members. The lateral tiebacks are usually geogrids that are buried in the stable area of the backfill. In addition to supporting the wall, the geogrids also stabilize the soil behind the wall allowing higher and steeper walls to be constructed.

Counterfort retaining walls have vertical precast concrete columns at regular intervals along the wall. These counterfort columns are T-shaped, may be tapered at the back and are anchored to the foundation by reinforcing or post-tensioning. Precast concrete panels are placed between the flanges of the counterfort columns to hold back the earth. Counterfort retaining walls resist the shear forces and bending moments imposed on the wall by the soil. Counterfort retaining walls are usually more economical than cantilever walls for heights above 7.5 m (25 ft).

Precast concrete crib wall systems use high strength precast concrete standard basket type units that are stacked and filled with earth for stability. After planting with ground cover, the wall becomes part of the natural environment. These walls offer stability and fulfill the concerns of citizens by providing sound reduction while conforming to the natural landscape. Crib walls can be used as retaining walls or slope stabilizers for earth or rock embankments, or as a noise freestanding barrier; especially suitable for highways, railroads and parks, gardens, residential and commercial districts.

Landscaping

Precast concrete landscape units are often used to beautify an urban setting. The look can be modern or rustic, simple or complex. A wide range of colours and architectural finishes are available. Further, precast concrete landscaping is functional in many forms such as seating, steps and paving. Consult your local CPCI member for input and cost information early in the design process.

Utilities

Light Poles and Utility Poles

Low maintenance, competitive price, and aesthetic appearance of precast concrete poles make them superior to steel or wood for use in utility, sports lighting, communication and area lighting applications. The ease and speed of installation means faster project completion and lower installed costs. Also, the use of concrete poles preserves our forests, requires no chemical treatment, and utilizes sustainable materials in production and placement. Other benefits include corrosion resistance, long service life—in excess of 50 years and minimal maintenance costs.

Precast concrete poles can save erection time and money by eliminating the need for anchor base structures which may take days or weeks to install. A precast concrete pole, under most conditions can be set in hours (drill a hole, place the pole, backfill with crushed aggregate, concrete or the original soil, then finish off with concrete or sod). This process eliminates unsightly base plates, studs or nuts that are normally used with steel poles. Precast poles are locally available. Contact CPCI for a certified parecaster.

Utility Products (Vaults, Culverts, Etc.)

Precast concrete drainage products, such as concrete pipe, manholes, catchbasins, and box units provide economical solutions to sustainable drainage systems with a variety of products for collection, treatment, grey water re-use, infiltration, attenuation and conveyance. Concrete pipe and culverts have a proven service life of more than 100 years and require minimal maintenance after proper installation.

Concrete pipe is manufactured in controlled production facilities where the quality standards are built into each pipe to ensure watertight joints are manufactured to close tolerances to speed up installation, and reduce inflow and infiltration for reduced maintenance and potential replacement costs for the life of the project. Reinforced Concrete Pipe are made in standard diameters of 250 mm to 3000 mm with full range of accessories and fittings available for all pipes, including bends, tees, end sections, headwalls and anchor blocks.

Concrete pipe can be safely and efficiently installed with mechanical installation equipment specifically designed to handle pipe and manhole products. Highly chemical resistant concrete pipe ensures the safe movement of sanitary effluent improving the environment of communities. Similarly, concrete pressure pipe used for drinking water is tested and certified ensuring that they do not contribute to potential adverse human health effects.

Precast Box Culverts are high quality, low maintenance concrete components that have a large number of applications including storm sewers, service tunnels, or small bridges and pedestrian crossings. Precast box units and project specific designed manhole structures are replacing the need for cast-in-place concrete structures. These precast components expedite the timeline for construction which in turn reduces social and economic impacts of traditional in-situ construction methods.

Precast Concrete Septic Tanks are a key part of household and commercial septic systems. Septic systems treat sewage waste in an environmentally responsible way. Tanks are available in a range of sizes to match the sewage load of any project, from 600 to 19,000 gallons.

Precast Concrete Catch Basins (CBs) are inlet devices that collect stormwater offline, and convey this flow to the storm system. Catch basin specifications vary region to region.

Detention/infiltration Precast Concrete Products take a unique approach, connecting individual precast concrete modules into a configuration that meets each project's requirements. This delivers a simple and flexible design solution without compromising above ground land use.

Many CPCI members make both standard and custom utility products. Consult a CPCI member near you. For drainage product technical information, consult the Canadian Concrete Pipe and Precast Association website: **www.ccppa.ca**.

Freight Handling/Storage Buildings/ Industrial Buildings and Structures

The ability of precast prestressed concrete to span long distances and carry heavy loads with minimum span/depth ratios are particularly useful in the construction of warehouses and industrial buildings. High strength precast concrete resists fire, moisture penetration and a variety of chemical substances. The clean, smooth surfaces obtainable in a precast concrete factory make this material ideal for food processing, computer component manufacturing and wet processing operations where cleanliness is a concern.

Precast floor and roof framing can be designed to accommodate a variety of mechanical systems and support heavy industrial uses such as hanging loads and bridge cranes. Precast insulated wall panels can be readily used as load bearing exterior walls or cladding. Exterior walls can be formed using standard shapes efficiently prestressed in long line production facilities. Custom shapes can be produced in architectural molds with a variety of smooth, sandblasted or exposed aggregate exterior surface finishes. Precast concrete resists abrasion, weathering and many harsh chemicals. Precast walls and ceilings can easily withstand high-pressure wash downs and cleanings.

Docks & Wharfs

Precast prestressed concrete is used extensively for the construction of docks and wharves, particularly on our East and West coasts—where marine traffic is highest.

Precast construction is the ideal solution for building over water where climactic conditions are variable and access is usually limited. Precast prestressed piles are often used to support dock structures. Precast fender panels can be designed to resist ship impact loads. Precast prestressed deck units will support heavy traffic loads on longer spans.

Precast concrete can be designed for long service life in harsh environments. The use of high strength low permeable concrete will protect the reinforcement and resist environmental damage.

Land Piles

Precast piles come in many different shapes and sizes: square (solid or hollow), octagonal, hexagonal and round. Sizes range from 250 mm to 600 mm for square piles, 250 mm to 600 mm for octagonal, 900 mm to 1350 mm for round piles, and 300 to 400 mm for hexagonal. Precast prestressed piles can double as foundations and piers where soil conditions are favourable. Where pile foundations are warranted, prestressed concrete piles can also serve as piers and abutments, thereby reducing the amount of on-site forming and concreting. The CPCI Design manual offers guidance on the section properties and factored resistance for the various pile sizes. Precast pile construction is also the ideal material for building over water where weather conditions are variable and access is usually limited. In these situations, precast prestressed piles are often used to support dock structures or to support bridge piers.

Prisons

Precast concrete has been put to good use for a variety of detention and correctional facilities and the support buildings that serve a vital role in institutional complexes. Precast concrete wall panels, framing and floor/roof slabs are excellent building components that are both durable and secure. Exterior walls can be comprised of precast insulated panels (sandwich panels) with an architectural finish and can function as the structural frame, building envelope and aesthetic exterior of the complex. Special security hardware is often specified. Security door and window frames can be pre-installed in the precast concrete elements at a CPCI member precast plant to save time and money.

On very large-scale projects, custom forms can be designed to produce special units such as entire single and double cell units. Otherwise, standard precast components can be successfully modified for prison construction. As in most precast structures, using practical and economical joint details is most important. All joint treatments should recognize realistic production and erection tolerances. Exterior joints should allow movement and be weatherproofed to prevent air and water infiltration. When joints are exposed in high security locations, they are generally sealed with high strength, non-shrink grout. This material can be used to seal narrow joints and fill the cavities over recessed structural connections.

Water & Sewage Treatment Plants & Tanks

Precast concrete tanks provide extra security for the contents and save time and money. Precast tanks can store or treat anything from potable water to hazardous waste to solid material. Storage capacities can range from 0.4 to 120 megaliters (100,000 to 30 million gallons). Precast concrete wall elements are usually pretensioned vertically in the precast plant and post-tensioned horizontally (circumferentially) through ducts cast in the panels. Joint closures are usually poured concrete on site. This method of sealing the joints allows the tank to perform (after post-tensioning) as a monolithic structure to resist hydraulic, temperature and seismic forces.

Off-site fabrication of wall and roof elements (under extremely well controlled conditions in a CPCI member precast plant) means higher quality and reduced labour on-site. Virtually any storage structure can be built using precast concrete. Other parts of a tank structure, such as columns, beams and roof slabs, may also be precast concrete. Contact CPCI for more information and design recommendations.

Mining, Oil & Gas Sector

Precast components have a multitude of uses in the mining, oil and gas sectors, owing to its ability to meet the demands of the harsh and, often times, aggressive corrosive environments. Uses range from tunnels, underground utility vaults, and utility buildings, to above and below ground drainage channels and chemical containment. Precast expedites the construction process in these typically remote areas, and enables construction to go unabated throughout the year regardless of the weather conditions. Total precast structures have also been used to construct quick and affordable housing for transient and permanent construction workers.

Tunnel Liner Segments

Tunnel liners are specialized precast concrete products that are cast in segments, and used to form a complete ring in large-diameter tunnels. Liner segments are manufactured to extremely tight tolerances, at a specific design radius. When installed in the field, they provide immediate and long-term support from earth and hydraulic pressures. The first segmental precast tunnel was built in North America in 1979 and precast segments are now routinely considered for a wide range of subway and rail tunnelling applications.

Precast tunnel liner segments offer expedient construction and are often considered as a risk management solution in difficult soil and rock situations where support is an issue. The use of precast concrete tunnel linings has increased due to its efficient and economical installation process compared to that of normal cast in-situ lining practice. Features of tunnel segments include segment thickness, length and radius designed for specific tunnel requirements, consistent quality, and long-term durability.

Special Applications & New Products

A high degree of design flexibility makes architectural and structural precast prestressed concrete ideal for a wide variety of innovative structures. Properties such as corrosion resistance (piling), durability (railway ties), fire resistance (pipe racks), tight tolerances (tunnel liners), architectural finishes (chimney stacks), strength (silos) and fast installation and economy (water tanks), are all used to good advantage. Where repetition and standardization exist, precast components can economically provide quality, plant manufactured products and eliminate expensive and risky field procedures. Precast concrete is in an ideal solution to projects in remote areas where local materials and labor may not be available. Further, Northern areas pose a challenge due to the shortened construction window. Precast concrete provides an optimal solution since all components are cast off site, throughout the year in an enclosed facility. New applications await the collaboration of creative designers and CPCI members.

The Hodder Avenue underpass incorporated full range of precast concrete elements and extensive use of ultra-high performance concrete (UHPC). In 2013 it was awarded the PCI Harry H. Edwards Industry Advancement Award (http://tinyurl.com/m984pp9) for its use of innovative materials and design, advancing the next generation of precast technology.

The Olympic Oval, constructed in 1986 for the 1988 Winter Olympics, is an example of a special application where the roof structure is constructed entirely of precast lattice arch structure with precast perimeter beams.

Vehicle & Pedestrian Bridges

Proven Economy

There were no prestressed concrete bridges in North America prior to 1950. Thousands of prestressed bridges have now been built in the past 50 years and many more are under construction in all parts of Canada and the US. They range in size from short span bridges to some of the largest bridge projects in the world. The design of prestressed concrete bridges is covered by CSA Standard CAN/CSA-S6-06 Canadian Highway Bridge Design Code specifications.

Prestressed Girder Bridges

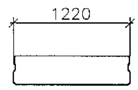
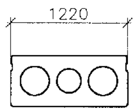
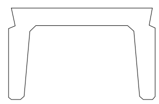
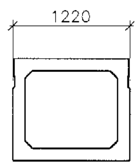
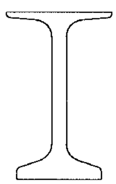
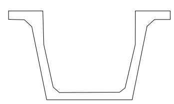
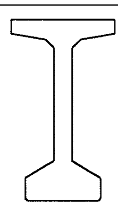
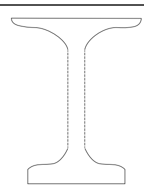
Precast prestressed concrete bridges have gained wide acceptance because of:

1. Proven economic factors:
    a. low initial and long-term cost
    b. minimum maintenance
    c. fast easy construction
    d. minimum traffic interruption

2. Sound engineering reasons:
    a. simple design
    b. minimum depth-span ratio
    c. assured plant quality
    d. durability

3. Desirable aesthetics—precast prestressed bridges can be designed to be very attractive.

Bridge designers are often surprised to learn that precast prestressed bridges are usually lower in first cost than other types of bridges. Coupled with savings in maintenance, precast bridges offer maximum economy.

Girder Type	Typical range of depths*	Typical span range*
 **Solid Slab Girders**	300 mm to 500 mm	5 m to 15 m
 **Hollow Slab Girders**	450 mm to 600 mm	9 m to 17 m
 **Channel Girders**	700 mm to 1100 mm	12 m to 23 m
 **Box Girders**	700 mm to 1200 mm	15 m to 35 m
 **Bulb Tee Girders**	1000 mm to 1800 mm	16 m to 42 m
 **Trapezoidal Girders**	1600 mm to 2200 mm	34 m to 43 m
 **I-Girders**	900 mm to 2300 mm	12 m to 45 m
 **NU Girders**	1000 mm to 2800 mm	27 m to 60 m

*Depths and spans for conceptual purposes only. Refer to the CPCI Design Manual for product information and capability. Chapter 7 provides dimensions, gross section properties and engineering capabilities of the shapes most commonly used throughout the industry.

Benefits of Precast Prestressed Concrete for Bridge Construction

Low Initial Cost

Precast prestressed concrete bridges are usually lower in first cost than other types of bridges. Precast bridges offer maximum economy with savings in time and maintenance.

Fast Easy Construction

Precast prestressed bridge girders require minimal lead times because they are locally manufactured in standard shapes and sizes. The precast components are easy to erect all year round. Simple connections join the deck girders to the substructure.

Formwork for the superstructure can be eliminated when the tops of girders are placed together to form the entire deck slab. Ties between adjacent units often consist of a grouted keyway and welded or transverse post-tensioned connections. For logging or low volume secondary roads, traffic can run directly on the girder deck.

Carefully planned details will speed the construction process and save budget expenditures.

Minimum Traffic Interruption

Maintaining traffic and eliminating detours are difficult problems for bridge owners. Precast prestressed concrete integral deck bridges can minimize traffic interruption because of the availability of long span, plant-produced sections and the speed of erecting a bridge. In emergencies, precast girders can be rush ordered and a bridge reopened in a matter of days or weeks using standard components.

Simple Design

Replacement of substandard bridges can be easily accomplished with precast prestressed sections. In some cases, existing abutments can be reused. In others, precast concrete piles, footings, abutments, wingwalls and piers can be precast and installed along with the deck girders.

Simple span precast bridge deck girders can be pinned to the abutments to resist horizontal earth pressures or be designed as integral abutments to eliminate troublesome expansion joints. Multi-span bridges can be made continuous for a smoother ride and to reduce the number of expansion joints.

Assured Plant Quality

Precast prestressed concrete products are inspected and quality controlled at the plant. Each operation in the manufacturing process provides an opportunity for inspection and control. During fabrication, prestressed beams are proof tested at release of prestress and subjected to some of the highest stresses they will ever encounter in service. CPCI member plants manufacture certified products per the CPCI Certification for Structural, Architectural and Specialty Precast Concrete in accordance with CSA Standard A23.4 "Precast Concrete—Materials and Construction".

Durable

Bridges are subjected to hostile environments as well as repeated impact loading. These structures must withstand not only freezing and thawing but artificial cycles of weathering and chemical attack through the use of deicer chemicals. High strength air-entrained precast prestressed concrete has excellent resistance to freeze-thaw and chloride attack. Prestressing enhances durability by placing the concrete in compression and eliminating most cracking at service loading conditions. Also, precast prestressed concrete bridges are non-combustible and resistant to damage by fire.

Aesthetics

Precast prestressed concrete bridges can be designed to elegantly blend harmoniously with their surroundings and offer an attractive view from above, beside and below. Strong, tough, durable yet graceful bridges can be constructed using the low depth/span ratios possible using high strength precast prestressed concrete and the simple clean shapes of locally available sections.

Minimum Maintenance

The overall economy of a structure is measured in terms of its life-cycle cost. This includes the initial cost of the structure plus the total operating cost. For bridges, the operating cost is the maintenance cost. Precast prestressed concrete bridges designed and built in accordance with CAN/CSA-S6-06 Canadian Highway Bridge Design Code specifications should require very little, if any, maintenance. Precast prestressed members are particularly durable because of the high quality of materials and construction used in their manufacturing.

Fatigue problems are minimal because of the minor stresses induced by traffic loads.

Of course, no painting is needed. Some bridge engineers estimate the life-cycle cost of re-painting steel bridges to be 10 to 20% of the initial cost. Painting bridges over busy highways, over streams, or in rugged terrain is very expensive and an environmental concern.

Shallow depth/span ratio

A common requirement of many bridges is that the superstructure be as shallow as possible to provide maximum clearance and minimum approach grades. Through the technique of pre-stressing, the designer can use the minimum possible depth-span ratio. Depth-span ratios as low as 1:32 can be achieved with solid slabs, voided slabs, box beams, channel slabs or bulb-tee sections. Even though deeper I-girder and bulb-tee sections will require less prestressing steel, the overall economy of a project may dictate the lowest possible depth-span ratio.

Contact your local CPCI members to discuss your next project.

Planning

1. Use locally available precast concrete members if possible. Precasting plants are equipped to furnish certain types of members. For short span bridges, designs using standard bridge sections will result in lower bid prices than unique designs.

2. Make precast members identical. Economy in precast manufacturing results from the production of identical sections. As an example, if a bridge consists of different span lengths, it is usually better to design all of the precast units with the same cross section rather than to design each span for an optimum depth-span ratio.

3. Work closely with local CPCI members throughout the planning stages. Ask for cost estimates as soon as sufficient data or plans are available so that cost savings can be incorporated well before bids are taken.

4. Set up bridge replacement programs to group several bridges into single contracts for optimum savings in fabrication, hauling, erection, and supervision.

5. For prestressed concrete bridges with cast-in-place deck slabs, use diaphragms only if required for erection purposes. Studies have shown that diaphragms contribute very little to the distribution of static or dynamic loads. Diaphragms at piers and abutments, i.e. those over supports, are useful in stiffening the slab edge.

6. Minimize skews wherever possible. If a skew is necessary, try to limit the skew to 30° or less. It may be less costly to lengthen the bridge slightly than to use an extreme skew angle to fit the bridge site exactly.

7. Use precast prestressed piles to double as foundations and piers where soil conditions are favourable. If pile foundations are warranted, prestressed concrete piles can serve as piers and abutments, thereby reducing the amount of on-site forming and concreting.

8. Use integral deck girders to eliminate the need for cast-in-place concrete deck slabs and to speed-up construction.

Detailing

1. Eliminate projections from the sides of the girders. Most precast prestressed concrete members are cast in precision-made steel forms. Form projections can be accommodated only by expensive modifications to the forms. It is better practice to use details that permit attachment by use of threaded inserts, weld plates, or through bolts to bolt or cast on projections after the girder is cast.

2. Use standard details recommended by local CPCI member manufacturers. Those are the details that can be made most economically.

3. Minimize the amount of reinforcing steel in prestressed concrete members. There is a tendency to add more reinforcing bars and welded wire fabric than is needed "just to be safe." Often the added reinforcement merely creates congestion making consolidation of the concrete difficult without contributing to the structural strength or behaviour.

4. Use elastomeric pads instead of metal bearing assemblies. Elastomeric pads, properly designed and installed, require no maintenance and will permit movements (due to temperature, shrinkage, and loads) to occur without distress.

References:

Wong, A.Y.C., and Gamble, W.L., "Effects of Diaphragms in Continuous Slab and Girder Highway Bridges," Civil Engineering Studies, Structural Research Series No. 391, University of Illinois, Urbana, Illinois, May, 1973.

Sengupta, S., and Breen, J.E., "The Effect of Diaphragms in Prestressed Concrete Girder and Slab Bridges," Research Report 158-1F, Center for Highway Research, The University of Texas at Austin, Oct. 1973.

Spliced Girder Bridges

Up until the mid 1960s, transportation equipment and available cranes limited the length of precast pretensioned girders to around 34 m. Practical girder weights and lengths can vary by province and by project—Designers should check with local producers as to the optimal solution for their project—girders up to 65 metres and 125 tonnes have been transported on the highway network in Alberta. Normally, precast girders can be fabricated and transported in lengths of 40 to 50 m and weights of up to 75 to 90 tonnes.

Some innovative designers began to look for ways to use the economy and high quality of plant produced precast girders for longer span bridges. Canadian engineers led the way in constructing long span prestressed precast girder bridges using spliced beams. Precast girder segments of manageable weight and length are transported to the site. Girder segments are either spliced and post- tensioned on the ground and launched or the girder segments are erected on temporary supports in their final position and post-tensioned together. The spliced girder method of construction has extended the practical use of precast beams to span lengths of 75 m or more by joining and post-tensioning girder segments at the site.

The benefits of a precast spliced girder system are:

Economy
Fewer piers result in lower overall cost, especially where soil conditions are problematic.

Safety
For overpasses, fewer piers result in longer sight distances and more spacious horizontal clearances. There is less likelihood of vehicle collisions with supporting columns.

Navigation
Across waterways, fewer piers allow improved navigation, better movement of ice and debris and minimal disruption to the natural environment.

Deck Joints
Fewer joints result in a smoother driving surface and less maintenance.

Aesthetics
Long span bridges tend to be more attractive.

Types of Splices

Reinforced splice
Precast girders are cast with splicing reinforcement projecting from the ends. The beams are positioned end-to-end on a temporary support, usually near the dead load inflection point, and concrete is cast-in-place at the splice. The girder segments are usually pretensioned to resist shipping and handling forces.

Cast-in-place post-tensioned splice
Precast girders are placed on falsework or temporary end supports, usually locate near the dead load inflection points. The joint is poured and continuous post-tensioning is applied. Mechanical keys are often used. Sinusoidal keys work well because they transfer shear more uniformly.

Stitched splice
This splice is a compromise between reinforced and post-tensioned splices. The ends of pretensioned segments are clamped together by short cables or threaded bars.

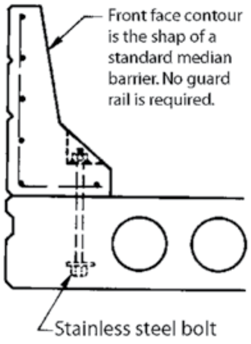
Drop-in splice
This splice is used when the erection of a temporary support is not feasible (e.g. over river crossings or traffic lanes). The splice may be designed as a hinge or post-tensioning may be applied locally to induce continuity.

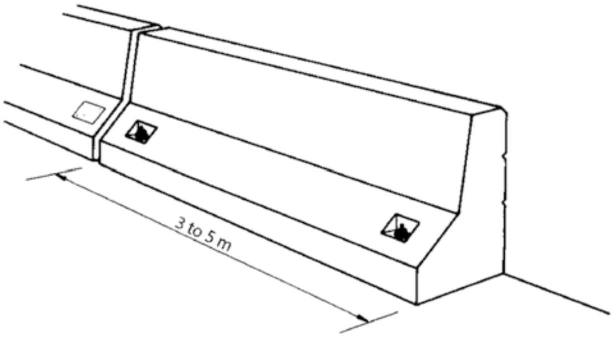
Structural steel splice
Steel plates are cast in the ends of girder segments to overlap at the matching ends of precast units. The plates are bolted together temporarily while free standing without support. The joints are later welded together and encased in concrete.

Epoxy-filled post-tensioned splice
Girders are aligned end to end, either in their final position or on the ground. The gap is filled with epoxy gel or grout and later the post-tensioning force is applied. A compressible gasket often protects the post-tensioning duct splice area. Match casting, while not essential, allows precision placement and expedites the work.

Spliced girder bridges have been constructed all across Canada with very good results. They allow the use of quality factory-made components for spans much longer than those spans where girders can be transported as single spans.

Traffic Barriers





Bridge Decks
Bridge decks often wear out well before the supporting beams. Some provinces have evidence that concrete bridges are more rigid than steel bridges and this results in superior deck performance (less cracking and longer life). Precast deck slabs can be used both on precast girder and steel girder substructures.

Precast concrete composite bridge deck panels are 75–100 mm thick slabs that span between the top flanges of concrete or steel beams. The panels provide a working platform for deck reinforcement placement and a stay-in-place form for the cast-in-place concrete overlay. Prestressing strands in the panels are perpendicular to the longitudinal axis of the beams and provide all of the positive reinforcement required for the span of the deck between beams. The panels are shimmed to the correct height and become composite with the cast in place overlay to resist superimposed dead and live loads.

Full depth precast concrete bridge deck panels are used both to replace worn or corroded decks on bridges where traffic must be maintained during the construction and for new bridge construction. Prestressing strands in the panels are perpendicular to the longitudinal axis of the beams and can be in two layers to provide all of the positive reinforcement required for the span of the deck between beams. The panels are shimmed to the correct height. Shear studs on the beams are grouted in place through pockets in the deck slabs. Edge grouting (and occasionally longitudinal post-tensioning) are used to tie the deck panels together.

Consult your local CPCI structural precast concrete manufacturer for their standard panel sizes and reinforcing layouts.

Pedestrian Bridges

Precast prestressed concrete is an ideal solution for pedestrian bridges. Bridges can range from simple double tees, bridge I or box girders to elegant custom- made cable stayed for road and river spans that enhance the user's enjoyment of the crossing.

CPCI Resources

CPCI Guide Specifications

Download these specifications at: **www.cpci.ca** — click on: Specifications

- Section 03 41 13 – Precast Concrete Hollowcore Planks
- Section 03 41 00 – Structural Precast Concrete
- Section 03 45 00 – Architectural Precast Concrete

These online specifications are updated to reflect changes in codes, standards and industry practices.

Detailed Design Information:

CPCI Design Manual

Manual contains comprehensive design and construction information in accordance with industry practice and Canadian design and construction codes and standards. Order from: **www.cpci.ca**

Designer's Knowledge Bank

The Designer's Knowledge Bank is a site created to assist design and construction professionals to understand precast-prestressed concrete products and structures. The material is free-of-charge and downloadable. Other material such as comprehensive hardcover design manuals may also be purchased through this site.

To access the Designer's Knowledge Bank, go to: **www.cpci.ca**

CPCI Members Near You and Your Project

To contact CPCI members go to: **www.precastsearch.com**

CPCI Resources Visit **www.cpci.ca/resources** to view these guides.

Technical Resources:

- Curing of High Performance Precast Concrete—Technical Bulletin
- High Performing Precast Concrete Building Enclosures—Rain Control
- Infrastructure for Life Publication
- Insulated Wall Panel Technical Guide
- Architectural Precast Concrete Technical Guide
- Structural Floor and Roof Technical Guide
- Structural Solutions Technical Guide
- Colour and Selection Technical Guide
- Effect of Accelerated Curing Conditions on the Performance of Precast Concrete—NRCC Report

Sustainability Resources:

- Precast and Sustainability
- Life Cycle Assessment of Precast Concrete Commercial Buildings
- LCA Product Transparency
- North American Precast Concrete Sustainable Plant Program
- CSCE—LCA for Sustainable Design of Precast Concrete Commercial Buildings in Canada

Other PCI Resources www.pci.org

- PCI Hollowcore Design Manual.
- PCI Parking Structures Design and Construction Manual.
- Peer-reviewed technical papers as published in the PCI JOURNAL.

CPCI Certification

How Precast Certification is a Requirement of the National Building Code of Canada

National Building Code of Canada (2010) – Division B:
Clause 4.3.3.1.(1) – Buildings and their structural members made of plain, reinforced and prestressed concrete shall conform to CSA A23.3, Design of Concrete Structures.

Clause A-4.3.3.1.(1) – Precast Concrete- CSA A23.3, Design of Concrete Structures, requires precast concrete members to conform to CAN/CSA-A23.4, Precast Concrete – Materials and Construction.

CSA A23.3 – Design of concrete structures:
CSA-A23.3-04 (R2010) – Clause 16.2.1 – All precast concrete elements covered by this standard shall be manufactured and erected in accordance with CSA A23.4.

CSA A23.4 – Precast concrete – Materials and construction:
CSA-A23.4-09 – Clause 4.2.1 – Precast concrete elements produced and erected in accordance with this standard shall be produced by certified manufacturers, with certification demonstrating the capability of a manufacturer to fabricate precast concrete elements to the requirements of this Standard.

It is not a requirement of the National Building Code, Provincial Building Codes or CSA Standards that products and systems are required to be certified by CSA, only in accordance with CSA.

CPCI Precast Concrete Certification Program for Structural, Architectural and Specialty Precast Concrete Products and Systems

The CPCI certification program is designed to qualify manufacturers who fabricate structural, architectural and specialty precast concrete.

Manufacturers must meet the requirements of CSA Standard A23.4, including Annexes A and B, together with PCI MNL-116 and 117 and CPCI certification requirements.

Manufacturers are evaluated on their quality system, documentation, production procedures, management, engineering, personnel, equipment, finished products and assemblies. Independent professional engineers conduct two-day audits twice annually.

Certification confirms a manufacturer's capability to produce quality products and systems.

The CPCI Certification Program assures project specifiers and owners of a Manufacturer's comprehensive in-house quality assurance program and acceptable production methods.

Purpose

The purpose of the audit program is to provide owners and designers with manufacturers who are:

- Qualified to manufacture the products they supply to the marketplace
- Competent to provide quality precast with adequate personnel and facilities
- Committed to improving the quality of their products and systems

Quality Audits are the heart of the precast certification program

- Audits ensure manufacturers have a quality system in place that is consistently adhered to
- Audits ensure adherence to national standards
- Audits ensure adherence to requirements of the precast certification program
- Audits evaluate and identify areas requiring upgrading or corrective action (continual improvement)

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Canadian Precast/Prestressed Concrete Institute
PO Box 24058 Hazeldean, Ottawa, Ontario, Canada K2M 2C3
Telephone (613) 232-2619 Fax: (613) 232-5139
Toll Free: 1-877-YES-CPCI (1-877-937-2724)
E-mail: info@cpci.ca