NOTE: The details shown in this design guide are intended to be helpful in the preparation of complete project plans. These details are not to be used as working drawings. Working drawings and details must be prepared and approved by qualified professionals certified in the jurisdiction in which the project is to be built. Shockey accepts no responsibility for any errors or oversights in the use of this material or in the preparation of plans. This publication is intended for use by professional personnel competent to evaluate the significance and limitations of its contents and able to accept responsibility for the application of the material contained herein. Special conditions and specific local requirements on your project will require specific evaluation and practical engineering judgment by the project’s Engineer of Record.

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INTRODUCTION

As the cost of real estate continues to rise, owners and developers are in greater need of parking solutions that provide smart and cost-effective answers to a variety of commercial, residential, municipal, and institutional parking needs. In addition to the practical issues relating to parking availability and cost, these owners and governing bodies are placing an increased emphasis on aesthetics. Today’s parking structure must be conveniently located, low-cost, and complement the surrounding landscape.

In this chapter we will explore the numerous benefits precast concrete offers for owners, designers and general contractors, including:

- Speed-to-market
- Durability
- Sustainability
- 50-Year Life Expectancy
- Integrated Project Delivery
- Increased Value for the Owner
- Openness and Security

Why Precast?

Why are more owners and designers selecting precast concrete as the material of choice for their parking structure projects? The answer is simple. Precast concrete is a highly durable, economical and versatile building material that offers incomparable value and flexibility. Its short erection time and ability to reduce the overall construction schedule appeal to owners and general contractors. For designers, precast opens the door to a world of literally limitless possibilities for providing “signature” solutions to their individual parking needs.

Speed-to-Market

The decision to design with precast concrete carries with it a myriad of advantages over cast-in-place (CIP) concrete or other traditional construction materials. One of the foremost benefits of using precast rather than CIP concrete is that the precast manufacturing process is unaffected by temperature or adverse weather conditions. Precast concrete components are fabricated in a controlled plant environment, which means that valuable project time is not lost waiting for acceptable weather conditions.

Typical precast parking structure components such as double tees, columns and inverted tee beams can easily be erected at an average rate of 12 pieces per crane per day, and can be erected in weather conditions that would be problematic for the full erection of steel components or CIP concrete. Precast concrete’s faster erection means follow-on trades can begin work more quickly and translates to an overall construction schedule that may be several months shorter than that of a project using CIP concrete.

For general contractors, this schedule reduction results in an economic advantage due to significantly reduced overhead (general conditions) and increased availability of the firm’s crews for other projects.
Durability
One of precast concrete’s foremost advantages is its durability. Plant-cast precast products are typically more durable than field-placed concrete in part because of the controlled environment in which they are manufactured. The low water-cement ratio used in precast concrete creates a denser product that does not allow penetration of chlorides and other harmful elements as easily as field-placed concrete. The Precast Prestressed Concrete Institute (PCI) PCI Handbook 6th Edition reports that studies have shown “accelerated curing makes precast concrete more resistant to chlorides than field-cured concrete.”

The Shockey Precast Group can use fly ash, silica fume, slag cement and other cementitious mixtures to help reduce the water/cement ratio of the concrete mix, increase density, reduce alkali silica reactivity, and increase the long-term strength and durability of our precast concrete components. The use of corrosion inhibitors and galvanized or epoxy-coated reinforcing in the precast concrete can further increase durability. To prevent corrosion of connections and to maximize the lifespan of a parking deck, The Shockey Precast Group uses stainless steel flange-to-flange connections in the driving surface where the majority of normal wear-and-tear will occur.

Sustainability
Silica fume, fly ash, and slag cement are all considered “green” products and their use as part of the overall concrete mix can add LEED points to a project.

50-Year Life Expectancy
In accordance with the Life-365 Service Life Prediction Model™, using slag with a corrosion inhibitor in our normal concrete mixtures, it can be shown that with a 1.9” cover to steel in our horizontal precast components, The Shockey Precast Group is able to provide parking structures that meet a 50-year life expectancy.

In the event a primary flange reinforcement is used that cannot corrode (such as the C-GRID® carbon fiber reinforcing system), durability of the double tees will be significantly greater than that of double tees reinforced with welded wire fabric.

Please note that achieving a 50-year life expectancy is contingent upon proper maintenance as outlined in PCI’s Maintenance Guide, including immediate repair of cracks and timely replacement of joint sealants to maintain protection of connections.

Integrated Project Delivery
Structural precast components can be erected in a relatively short period of time because they interlock to support one another. Simpler installation requires fewer crew members, which translates to less traffic, congestion and waste on the job site. For the general contractor, a cleaner and safer jobsite means less risk and more assurance of a smooth and successful project flow. And because The Shockey Precast Group manufactures and erects its precast components, the general contractor can rely on a sole subcontractor for project completion.

Increased Value to Owner
For the owner, the “speed to market” of precast means faster delivery of the finished parking structure, which can result in significant cost savings and translate to a faster return on investment. The durability and longevity of a precast parking structure also equals a better long-term investment for the owner. As previously stated, the inherent quality, strength and density of precast concrete produced by The Shockey Precast Group, combined with
a regular maintenance program, can result in a parking structure with a typical life cycle of 40-50 years – far greater than the typical life cycle of a CIP parking structure. For the owner, this represents a significant return on the initial investment.

**Openness and Security**

Anyone who has ever parked in a dimly-lit, closed-in parking garage understands perfectly the aesthetic and security-related advantages of a precast parking structure. The use of long-span precast double tees and architectural load-bearing spandrels or load-bearing walls allow designers to create parking structures with wide bays that give patrons an increased sense of visibility and security. The end result? More patrons are likely to use the precast parking structure than a dimly-lit, closed-in CIP parking structure.

**Why Shockey?**

**The Shockey Pedigree**

Why choose The Shockey Precast Group? The Shockey pedigree is synonymous with quality, integrity, and doing a job right the first time. Our history stretches back more than 100 years, encompassing general contracting, design build and precast concrete services.

In 1896, Howard Shockey started a wagon-repair business in Winchester, Virginia. The business grew to include general contracting and Howard’s reputation for quality construction and do-it-right-the-first-time attitude quickly put his company in demand for custom home building. Today, many of the homes he built at the turn of the century are still standing; monuments to his legacy of hard work, integrity, and dedication. Howard passed that legacy to his sons, and in the 1930s, Jim Shockey joined his father in the business. He was later followed by his brother Ralph. In 1947, the company became known as Howard Shockey and Sons.

In 1955, Shockey opened a small manufacturing facility for prestressed concrete as a division of Crider & Shockey, its former ready-mix concrete company. One year later, Shockey Brothers, Inc. became the third Shockey operating company. In 1999, the company changed its name to The Shockey Precast Group. Today, The Shockey Precast Group has completed more than 3,000 precast projects throughout the Mid-Atlantic region, including these recent noteworthy parking structures:

- Calvert St. Parking Structure, Annapolis, MD
- D.C. Nationals Ballpark Parking Structures, Washington, D.C.
- Gaylord National Harbor Resort & Convention Center Parking Structure, Oxen Hill, MD
- John Paul Jones Arena Parking Structure, Charlottesville, VA
- Carilion Healthcare Riverside Parking Structure, Roanoke, VA
- Shady Grove Metro Station Parking Structure, Shady Grove, MD
- Fairfax Judicial Center Parking Structure, Fairfax, VA

The Shockey Precast Group is a charter member of the Precast/Prestressed Concrete Institute, as well as being a PCI-Certified Plant and PCI Certified Erector. Shockey Precast management has held leadership positions in MAPA, the
PCI chairmanship, various PCI technical committees, and on the PCI Industry Advisory Group to the National Building Information Modeling Standard Initiative. The Shockey Precast Group is also a member of the AltusGroup – a collaboration of precasters dedicated to advancing the use of C-GRID® carbon fiber reinforcing.

**Sole Source**

The Shockey Precast Group provides the Owner, Designer and General Contractor with a single point of contact for the full range of precast activities from initial coordination and design through turnover of the building to the owner. With 50+ years in the production and erection of precast concrete, The Shockey Precast Group’s experience in the parking structure arena is unmatched in the region -- making us truly The Partner of Choice.

The Shockey team assists the Owner or General Contractor through the entire design and construction process starting with early budgeting information. We strive to be part of the early design process, providing experience-based budgets in support of specific project plans to assist the Owner or General Contractor in long-term financial forecasting of projects. As planning continues and details of the structure become more defined, we assist in defining the cost of a precast structure by offering a comprehensive proposal for the project.

The project proposal includes a detailed engineering and production schedule that enables the Owner or General Contractor to meet project erection needs. The Shockey Precast Group typically assists the Owner and General Contractor by providing quality coordination efforts to the team throughout the design development process.

Shockey’s team includes field-experienced coordinators who specialize in onsite management of pre-erection activities to facilitate a smooth transition to the erection phase of the project. Our transportation coordinators ensure the site logistics details are planned well in advance to allow for uninterrupted erection of the precast. After erection is completed or has advanced to a safe degree, our Field Coordinators provide early access to
the structure for follow-on trades. This timely onsite coordination minimizes disruptions of field activities and reduces the overall project construction schedule.

During erection of the building, The Shockey Precast Group’s field finishers complete the onsite work -- enabling the precast portion of the structure to be completed within a month of erection completion. This quick response allows punch-list review of the structure to proceed without delay. Finally, upon completion of the precast work, we provide an industry-leading manual for care and maintenance of parking facilities, along with a warranty of our work. Owners who follow the cyclic maintenance activities outlined in this manual and who have trained personnel responsible for the care of their parking structure will ensure the structure meets or exceeds the service life objectives. The Shockey Precast Group’s field representatives also provide experience-based assistance to the owners on an as-needed basis during parking structure operations.

From design development through on-line operations, The Shockey Precast Group provides one-stop service for all the activities necessary to bring a new parking structure to reality.

**Design Assist Program**

In 1996, legislation was passed that enabled the federal government to enter into design-build contracts. Since that time, there has been a dramatic rise in the number of federally-funded design-build projects. As a result, the need for specialty subcontractors to support this significant increase has never been greater.

The Shockey Precast Group typically seeks to become involved in the development of projects that are less than 15% designed. Early involvement in the design process enables The Shockey Precast Group to help our customers make sound, informed choices that best serve the financial and aesthetic needs of the owner.

**Design Assistance Services**

The Shockey Precast Group provides the following design assistance services to our customers:

1. Prepare and update budget estimates.
2. Participate in constructability reviews.
4. Attend meetings with the A/E Design Team as required.
5. Provide assistance to the A/E Design Team in the form of construction details, loading concepts, product samples, and drawings from similar products.
6. Participate in regular phone, written, and email communications with the A/E Design Team during the development of the design through 100% Construction Documents.
7. Use BIM Process to provide 3D project models.
**Frequency**

The Shockey Precast Group provides design assist program services with the following frequency:

1. At Core and Shell 100% Design Development Documents.
2. At 10%, 50%, and 100% Construction Documents.

**Building Information Modeling (BIM)**

“A Building Information Model (BIM) is a digital representation of physical and functional characteristics of a facility. As such it serves as a shared knowledge resource for information about a facility forming a reliable basis for decisions during its life-cycle from inception onward.

A basic premise of BIM is collaboration by different stakeholders at different phases of the life cycle of a facility to insert, extract, update or modify information in the BIM to support and reflect the roles of that stakeholder. The BIM is a shared digital representation founded on open standards for interoperability.” — National Institute of Building Sciences

The Shockey Precast Group’s Engineering department has played an integral role in the development of BIM for the precast industry through its partnership with TEKLA Structures. This commitment to remaining at the forefront of BIM technology has made The Shockey Precast Group instrumental in the advancement and use of BIM throughout the precast industry. For our customers, The Shockey Precast Group’s extensive knowledge and use of BIM technology means we can maximize the effectiveness of this valuable integration tool to ensure smooth project flow and open team communication.

**Safety: First at All Levels**

The Shockey Precast Group is committed to providing a safe and healthful work environment for all our employees and others who may work, visit, or enter our facilities or jobsites. It is our policy to conduct business in a manner that offers maximum protection to each and every employee and any person that may be affected by our operations and business. We will make every effort to provide a working environment that is free from any recognized or potential hazard. The commitment is best described by the Shockey maxim — **Safety: First at all levels.**

The groundwork for a safe and successful project is established long before the first piece of precast is delivered to the site. The Shockey Precast Group is proud of its thorough pre-construction planning and safe execution of all work activities. Shockey managers and field operations experts mentally build the project, anticipating as many issues as possible that could adversely affect the progress of the work on site. Thorough on-site review of access requirements for the crane and trucks transporting the precast are discussed long before the first layer of topsoil is disturbed.

During the project proposal stage, the Field Operations Manager, with assistance from The Shockey Precast Group’s Estimating Department, uses available contract documents to determine the safest and most economical method for erecting the precast. The Field Operations Manager determines required access for the crane and establishes the size of the crane, lengths of boom, and boom configuration required to safely erect the precast well within the crane-specified capacities. An access sketch showing the required crane path is provided with each proposal. Additionally, the crane geometry (length, width) and the maximum crane bearing pressure are provided so the owner can determine costs for
providing stabilized crane access and a stable base course to support the trucks providing precast delivery to the site.

Erection of the precast is performed by erectors Qualified under PCI’s Erector Certification Program. PCI-Qualified Erectors must undergo a rigorous audit of their erection operations at least every six months. Any deficiencies found during the audits are immediately corrected. Follow-up audits ensure continued compliance with this safety-oriented Certification Program.

During the design development stage of all awarded projects, the precast design engineer uses the erection plan to determine if additional erection bracing is required. The precast design engineer evaluates the stability of the partially erected structure to ensure it can withstand the most severe weather conditions at any point during erection. If additional erection bracing is required, the erection bracing plan with specified bracing details will be incorporated into the erection plan for the structure. The design analysis and details will be sealed by the precast design professional.

Internal preconstruction meetings between the erection foreman and the precast design professionals and on-site preconstruction meetings between the General Contractor, Inspection Agencies, and the Engineer of Record, are held to ensure that all aspects of precast erection are fully understood and agreed upon. This includes in-depth discussions on precast connections and required erection bracing.

A pre-erection survey of the CIP concrete or steel substructure supporting the precast is completed well in advance of erection so any required modifications or repairs to the CIP or steel can be accomplished without affecting the erection start date. Erection commences only after assurance from the Engineer of Record that the CIP has achieved required strength or the steel structure is ready to accept precast.

The erector is required to develop a site-specific Safety Plan for each project. This plan contains a complete hazard analysis and fall protection planning for the project. Prior to start of the erection, the erection crew is fully briefed on the Safety Plan and understands the safety constraints of the project. This includes handling of the types of precast products for the project. All precast delivered to the project arrives with a shipping and handling tag attached. This tag outlines the specified method of erecting the panel and gives any special handling instructions for rotating or rolling the precast. Weekly follow-up safety meetings sometimes referred to as “Tool Box Talks,” are held onsite for the duration of the project.

During erection of the precast, the erection foreman is responsible for safety on the project. The foreman continually observes the work of the crew to ensure compliance with the published Safety Plan. Proper safety marking of the site is maintained in accordance with the Safety Plan and the foreman ensures that non-erection personnel remain outside the erection area. Only when the properly documented turnover of the erected structure has been completed will non-erection personnel be allowed to perform work on the structure.
John Paul Jones Arena Parking Structure, University of Virginia, Charlottesville, VA
Bay Size
The Shockey Precast Group's 48' bay module uses 12' wide double tees, which result in the most cost-effective use of precast components. Based on the 12’ double tee width, this handbook will offer a possible “typical” parking structure layout. Whenever possible, limit the use of non-standard tee widths or bay sizes, as this will influence the cost. The bay size you choose may result in very different spandrel dimensions, floor to floor heights, drainage plans and/or supporting wall systems.

Drainage
For owners and designers, assurance of a proper drainage system is one of the most important considerations in the design of a parking deck – both for the health and life of the deck as well as for the comfort and convenience of its patrons. The use of a “dry system” for washes that direct water toward the drain is considered superior to the use of CIP concrete pour strips. While CIP toppings, such as those used in pour strips, typically feature a 3,000 psi concrete mix, the concrete used for a precast dry system will use a 6,000 psi mix. Since the precast dry system is produced in a controlled plant environment, it is monitored by the PCI Quality Control program. The quality of CIP wash castings may not be controlled in the same manner.

Designed correctly, an effective drainage plan will help prevent water from ponding or causing premature degradation to the joint interfaces. Generally, drains are located at the interior bays, at alternating grid lines. One economical way to provide proper deck drainage is to “warp” the deck surface. Warping occurs when the deck perimeter is held at a constant elevation and the interior bays are alternately raised and lowered. Warping is generally not cause for concern regarding cracking of the double tee surface, provided the warp is held to a limit of .175 inch per foot of width for a 60’ long tee. Please reference PCI Journal January/February 2003, page 35 for standard industry practice. The following diagram provides an illustration of this concept.
While warping of the deck surface is an option worth considering, it is also possible to alternately raise and lower the perimeter of the deck equally with the interior bays, resulting in a two-way deck cross slope. This eliminates the need for warping tees but, in turn, tends to be less cost effective. The amount of cross slope along the length of the tee will depend on the deck system and bay size chosen. Either option is possible and may or may not be suitable to the design in question.

A few important drainage facts -

- The Shockey Precast Group casts pre-manufactured drain units into the flanges of the double tees that provide cost economy and better sealing quality compared to field installed varieties and eliminates field cutting and installation.
- The Shockey Precast Group’s “total precast” deck surface does not rely on the use of field topped CIP concrete. This represents a substantial advantage over other precast systems and provides better durability and lower costs. It also minimizes the chance for water infiltration at the precast interface.
- The Shockey Precast Group can divert water toward the drain using one of three possible systems: precast curbs, monolithic precast washes, or CIP washes.
- Locating handicapped parking spaces should include consideration of maximum allowable slope.

**Drainage Considerations**

The movement of water from the deck surface is illustrated below. The sloping of the deck structure enables the water to be directed to strategically located drains. This sloping has a very significant effect on structure framing. Therefore, early determination is critical and vital to floor heights.
Expansion Joints

Under normal seasonal heating and cooling cycles, concrete will expand and contract. This in turn generates in-plane forces and displacements that must be accounted for. Expansion joints, when correctly located, allow these effects to occur without adversely affecting the precast joints and connections. Depending on the deck configuration, expansion joints should be located a maximum of 300 feet apart. The expansion joint is frequently located at the joint between two tees at a column gridline and should be large enough to accommodate the combined thermal movement on each half of the structure. The location of the shear resisting elements also plays a role in determining the location of expansion joints. If, for example, a 300’ long deck contained stiff, shear-resisting elements on both ends, it might be advisable to introduce an expansion joint somewhere in the middle of the deck to help “relieve” the build up of stress at the ends. This is because shear elements act as “points of fixity” and will act to restrain the deck, thereby causing connection forces to exceed reasonable limits. It is essential to remember that expansion joints also serve to interrupt the lateral force resisting system, which, for the purposes of design, effectively creates two separate building structures. Each building half must contain sufficient lateral load resisting elements.
General Loading
A parking garage must satisfy a variety of loading requirements. In addition to their own self weight, parking garages are designed to resist uniform vehicular loads of 40 psf or the application of a 3,000 pounds acting on an area of 20 square inches (typical size of the base of a tire jack). If higher loading criteria are needed to resist fire trucks or other large vehicles, special provisions may be required, including the deepening of elements or the addition of reinforcing. Other loads include wind or seismic, as determined by the applicable building code.

Seismic/Wind Considerations
Parking structures typically utilize shear walls to resist the lateral wind or seismic forces prescribed by local building codes. Depending on location and site conditions, the design loads will vary, as will the number or size of shear walls needed. Shockey engineers always perform a comprehensive lateral load analysis of each building the company designs. Loads from this analysis are then given to the Engineer of Record for verifying the CIP footing and wall designs.

When possible, it is advantageous to provide shear walls located along the line of ramp walls with an additional wall on each end of the ramp as shown in the figure below. Another option, depending on the prescribed loads, is to offer the shear walls with “punched” window openings to provide additional light and openness. Horizontal ramp walls can be used to provide the required lateral stability parallel to the ramp. These walls have openings to provide light and openness.

Walls should be located in a way that takes maximum advantage of the surrounding dead load elements. Shear walls that support double tees or inverted tee beams will “engage” more dead load, which helps to counteract the wall overturning moment. When overturning moments are larger than dead load resisting moments, a condition known as “net uplift” on a shear wall element occurs. This requires the design of hold-down devices or connections, which, in turn, increases cost.

Since the design of the CIP footings and walls is the responsibility of the Engineer of Record, it is important that sufficient thought be given to shear wall placement early in the design process. The Shockey Precast Group is able and qualified to work with the project engineers to help develop rational, economical and practical load-resisting systems that will provide superior building performance.
**Floor-to-Floor Height**

The floor-to-floor height of a parking structure depends on a variety of factors, including the precast elements used and the usage requirements of the occupants. The sample parking structure included in this handbook suggests a floor-to-floor height of 10’-8” This height provides for optimal economy and allows a minimum 7’-0” vertical clearance under the inverted tee beams.

**Fire Resistance**

Depending on numerous factors, a parking structure may be required to have either a 1-hour or 2-hour fire rating. Most parking structures fall under the category type IIB, as defined by the International Building Code, and do not require any particular fire resistance rating at all. However, when required by design, precast parking structures can easily be designed to a higher level of fire resistance.

Fire resistance ratings of precast components are measured and specified according to the common standard, ASTM E119. Fire endurance is defined as the period of time elapsed before a prescribed condition of failure is reached during a standard fire test. Designing precast elements to satisfy a given fire resistance rating will increase costs to some degree – primarily when additional reinforcing or larger member sizes are needed.

**Openness**

A primary benefit of the 48’ bay is that there are fewer vertical elements to interrupt the natural sight lines. The inherent openness of a 48’ bay parking structure contributes to increased security of parking structure patrons and provides natural ventilation.

**Joints and Reveals**

Joint sizes between precast and CIP elements vary. Recommended nominal joint dimensions are noted in this handbook. These joints have been established based on tolerance requirements (see section below), and to ensure a long-lasting joint interface.

When discussing these joints, it is important to understand that the dimensions given are
“nominal” – meaning actual joint sizes are allowed to deviate from these values to within industry accepted ranges, as described in PCI MNL 135. When selecting accent reveals or rustication lines, it is important to tie them to the chosen joint size. Avoid triangular reveals where possible because they are difficult to affix to the forms. Instead, a trapezoidal reveal will provide a flat nailing surface for the form builders and help minimize possible nail hole irregularities. When choosing a reveal size, consider limiting the depth to ¾”. Deeper reveals decrease the effective section of the panel. This reduces panel strength and increases the chance for panel cracking, which may require an increase in the panel thickness. Be sure to include reveals between any and all color breaks -- when two separate face mixes are used within the same panel, it’s strongly recommended that designers include a reveal between the two mixes to provide the casting crew a distinct stopping point and help reduce color bleed. This will help ensure a smooth break line between the two colors, as illustrated in the figure below.

**Corners and Quirks**

When considering details at building corners, it’s recommended that a ¾” quirk be introduced at panel returns – especially those exceeding 1’-1” in length. To achieve a superior finish along the panel face, panels are often produced in two phases, which results in a casting or pour line between the two pieces (see sketch below). The quirk will minimize this effect by essentially hiding the line in the apex of the notch.
Facial Projections

Facial projections can add a unique accent to your building project. Because these features are cast to the panels “bottom in form”, a minimum draft dimension is necessary in order to be able to strip the panels out of the forms. Without proper draft, suction forces generated between the concrete and the form may cause the panels to bind up during stripping and possibly damage the panel and/or forms. To ensure this does not occur, Shockey recommends a minimum draft of 1:6 on facial projections, as noted in the sketch below. Also keep in mind that facial projections increase production costs, since forms need to be built up to accommodate the feature.

Tolerances

Precast connections and panel dimensions need to allow for industry standard tolerances. An excellent guide to precast tolerances is available through PCI. The Tolerance Manual, MNL 135, describes in detail the allowable production and erection tolerances for various precast elements. Request a copy at www.shockeyprecast.com.

Penetrations

Vertical penetrations through the double tee flanges can be located anywhere except in the stem. Penetrations through the precast that may be required for wall hydrants, pipe penetrations and light fixtures can be cast into the panels provided the coordination for location and size is done early enough in the shop drawing development. The location and size of these penetrations should be furnished to Shockey during the shop drawing process. This is to ensure that the information can be incorporated into the shop drawings and fabrication drawings in adequate time. For openings less than 10” square, it is recommended that the penetrations be field cut.

Connections

Design of the connections is always the responsibility of the precaster. Shockey utilizes a variety of “user-friendly,” safe and efficient connections that allow precast elements to be set and secured in a timely fashion. Included in this handbook are a number of typical
connections which provide the designer with a solid basis for cost effective and highly efficient designs. Depending on various factors, including life expectancy and durability requirements, embedment finishes will vary from job to job. The Shockey Precast Group typically recommends the following plate finishes:

- Non-welded plate connections exposed to the elements: Hot-dipped galvanized or ’J’ Finish
- Welded plate connections exposed to the elements: Zinc Rich Cold, Galvanizing Coated
- Rods and Bolts: Electroplated
- All other material: Plain
- Flange-to-flange shear connections: Stainless steel

Maintenance
Ensuring long-lasting durability of a parking structure requires owners take the necessary steps to maintain the structure once completed. Properly maintaining a parking structure necessitates regular inspections and cleaning of the precast joints, and a range of other items. The issue of snow removal should be addressed early in the design phase with owners so it does not become a source of concern once the snowplows begin their work. For example, the improper mounding or removal of snow can cause a degradation of the joints or tee surfaces.

CIP Concrete
CIP concrete is typically not included in the precast scope of work. However, since CIP interfaces with the precast elements, the coordination of precast to CIP interface is extremely important. CIP elevations and details should closely match the precast design to ensure the proper fit-up and execution of the pieces when they arrive on site.

Following is an explanation of each design team member’s responsibilities regarding the coordination of CIP-to-precast interface:

- **Engineer of Record (EOR)** – The EOR should specify top of CIP pier, wall and footing elevations and provide adequate reinforcing details of these elements within the contract documents. Pier and footing designs should account for the possibility of uplift and sliding forces at shear wall locations. Reinforcing details should specify adequate confinement steel at the tops of piers and walls, as required by the ACI code. Pier and wall sizes should typically be a larger dimension than the precast they support so that anchor bolts and embedded plates can be easily placed within the confinement steel. Dowels or anchor bolts used to connect the precast to the CIP are typically the responsibility of the precaster. In many cases, The Shockey Precast Group may suggest alternate top of pier or footing elevations that either enhance the structure's performance or improve cost-effectiveness. In this case, the CIP subcontractor is asked to execute the details according to the precast drawings, since this is how the pieces are fabricated.

- **General Contractor (GC)** – Coordinate top of CIP pier and wall elevations with the structural and precast drawings. Ensure that the CIP subcontractor follows and properly executes the reinforcing details that are shown on the Contract Drawings (see notes above).
• **The Shockey Precast Group** – Design and prepare anchor bolt layout drawings for use by the GC and CIP subcontractor. Supply all loose hardware and anchor bolts needed for the attachment of the precast elements to the CIP concrete.

• **CIP Subcontractor** – Carefully execute the CIP reinforcing layouts per the structural drawings, including the confinement ties located near the tops of piers and walls. Incorporate loose hardware for the precast connections according to the locations shown on the precast layout drawings. When a discrepancy exists between the structural drawings and the precast drawings for top of CIP elevations, the precast drawings govern.

The following sketch illustrates the CIP-to-precast interface:

It is generally recommended that the CIP system be designed such that the precast elements are not required to retain earth loads. Instead, CIP retaining walls can be provided that act independently from the precast to withstand these forces. If necessary, it is possible to design the precast tees or walls below grade to act to resist earth loads, as shown in the following sketch. This could influence the location of shear resisting elements, connections, and may necessitate the use of a cast-in-place topping on the tees.
The 48' Bay System

To illustrate the typical path that The Shockey Precast Group’s design-assist effort would take, please consider the following example:

The Shockey Precast Group is approached by a potential customer, who brings to the table this information regarding a parking structure:

1. The structure must have a floor-to-floor height of 11’8” grade to first elevated level, and 10’8” on all other levels.

2. Ramp slope is 6.1% at the first level, and 5.6% at the upper levels.

3. The 256,000 SF structure must be designed to accommodate 790 cars.

Using this information, The Shockey Precast Group will work with the design team to achieve an optimal layout using the 12’ double tees and 48’ bay system. On the following page is an example of owner-provided sketches typically received by The Shockey Precast Group at the beginning of the design-assist process:
Using the owner-provided sketches and basic deck requirements as a guide, The Shockey Precast Group works with the project design team to develop a customized 48’ bay solution that meets the owner’s needs and satisfies the designer’s vision. Specifics of the deck are listed below:

**Deck Type**
- 12’ wide, 30” deep tees
- 48’ wide bays
- 10’-8” floor to floor height
- 7’-0” min free vertical clearance
- 192’ long ramp with a 5.55% slope
- 177 parking spaces per typical level

The following pages illustrate the typical precast components and connections that comprise The Shockey Precast Group’s 48’ bay system. These details are included to give the designer a better understanding of the 48’ bay module as a whole, and to give insight as to necessary design considerations specific to precast concrete parking structures.
TOTAL SQUARE FEET PER GROUND FLOOR (C.I.P.) LEVEL = 46,654 SF

FOUNDATION PLAN - GROUND FLOOR C.I.P. LAYOUT
NUMBER OF PARKING SPACES PER FIRST FRAMED LEVEL = 155

FOUNDATION PLAN — GROUND FLOOR PARKING LAYOUT
TOTAL SQUARE FEET PER FIRST FRAMED LEVEL = 52,359 SF

FIRST FRAMED LEVEL (SECOND FLOOR) PRECAST LAYOUT
TOTAL SQUARE FEET PER TYPICAL LEVEL = 52,359 SF

TYPICAL FRAMED LEVEL (3RD, 4TH & ROOF) PRECAST LAYOUT
NUMBER OF PARKING SPACES PER TYPICAL LEVEL = 177

TYPICAL FRAMED LEVEL (3RD, 4TH & ROOF) PARKING LAYOUT
South Building Elevation (Highlighting product description)

North Building Elevation (Highlighting product description)
East Building Elevation  (Highlighting product description)

West Building Elevation  (Highlighting product description)
3D VIEW

West Elevation at Stairwall (Highlighting stairwall cut away)

Longitudinal Building Cross Section at Ramp walls
Building Cut-Away Section Illustrating Building Assembly
Pocketed Shear Wall Details
Horizontal Ramp Wall and Details
RAMP WALL ELEVATION

(USING VERTICAL WALLS)
12' Wide Double Tee Profile W/6'-0" Stem Spacing
12’ Wide Double Tee Profile W/ 5' - 0” Stem Spacing
Inverted Tee Beam Profile Detail
Deck Drain Details

- Drain Hole
- Dimensions:
  - 1’ - 2 1/4”
  - 1’ - 0 1/2”
  - 1’ - 17/8”
  - 0”
  - 11 3/4”
Plastic insert blockouts are used for electrical use typically. Conduits are threaded through 3”x6” openings during the erection process. See G/C note below.

**Double Tee Elevation**

Locations are normally at 1/3 points but can vary per condition on job.

**Double Tee Flange**

**Double Tee Stem**

6”x3” OPCG

G/C Note: SPC recommends coordination with Shockey to place conduit during the erection process.

**Stem Block-Out Details**
Double Tee to Flange Chord Connections
Column to CIP Footing or Pier

**NOTE: 2” MIN.**

- PRECAST COLUMN
- BASE PLATE
- ANCHOR BOLT
- ANCHOR BOLT POCKET AT EACH CORNER

**NOTE: PIER & FOOTING REINFORCING TO BE DESIGNED & SPECIFIED BY THE STRUCTURAL ENGINEER & SUPPLIED BY THE GENERAL CONTRACTOR**

- GROUT
- ADEQUATE CONFINEMENT STEEL BY G.C.
- FOOTING OR PIER
- GROUT UNDER COLUMN
- STEEL SHIMS (4) LOCATIONS
Double Tee to Spandrel Connection Details
Double Tee to Spandrel Details Corbel Detail
Double Tee to Spandrel Connection Details Top Connection
Double Tee to Beam Connection Details
Non-Load Bearing Spandrel to Column Connection
Load-Bearing Spandrel to Column Connection
Outboard Column Option
The Shockey Precast Group’s 48’ bay module offers incomparable efficiency and cost-effectiveness for the owner. The following chapter highlights the flexibility and freedom available to the designer through the 48’ bay module.

PARKING STRUCTURE AESTHETICS

The days of plain, gray, box-like parking structures are over. Savvy owners and designers are taking advantage of the nearly limitless design freedom offered by precast concrete. At Shockey, we help our customers realize their unique project visions with individualized precast solutions that are durable, cost effective and beautiful. In this chapter, we will explore the variety of finish options available with precast concrete from Shockey.

Color, Textures and Applied Finishes

Through a variety of aggregates, choice of matrix colors, varying depths of exposure, and finishing techniques, precast can meet almost any color, form or texture that may be specified by the designer. Additionally, the beauty of natural aggregates is greatly accentuated when the aggregates are fused with the color and texture benefits of precast.

Color

The Shockey Precast Group recommends that color selections be made in the same or similar lighting conditions as the final, in-place conditions. In order to maintain matrix color uniformity, white cement should always be used along with color pigments conforming to ASTM C979. Even when the desired matrix color is gray, the use of white cement and gray pigment is still highly recommended.
When reviewing cost in selections, it is important to consider the source of aggregate if deep exposure is required (local sources are almost always more cost effective); and to realize that matrix colors such as blue and green are higher cost selections.

Variations in color can be achieved within areas of the structure or within each individual precast unit. Use of multiple colors requires clearly defined color breaks, which can be achieved with reveals, joints and profile changes to ensure crisp transitions.

Deep exposure finishes can be achieved either through the use of chemical retardants or through the sand-blasting process. In both cases, more than just the extreme surface area of the aggregate is exposed, allowing the coarse stone aggregate to project beyond the cement matrix. The exposure should remain at 40% of the narrow diameter of the coarse aggregate in order to prevent the occurrence of “bald spots.” Both types of surface treatments highlight the natural beauty of the stone while providing a texture that cannot be obtained through the use of lighter finishing techniques.

Texture
Texture expresses the natural beauty of the material components and can be used to define or accentuate specific areas of the structure’s façade. Texture takes advantage of its changing relationship to light to create a range of surface differences from subtle to dramatic. When changing textures or exposures within a single precast unit, clear and well-defined break points are needed similar to those for color. Textured surfaces also have the added benefit of hiding the effects of weathering and high-volume use areas since the irregularities in the surface help divert attention from line streaking and diminish traffic use marks.

Texture can be achieved through a variety of different techniques, and can range from light exposure to deep exposure.

Applied Finishes
These are a variety of post-applied techniques used to achieve the desired appearance and character of the façade. The structure’s final appearance is obtained through the combination of mix design selection and the choice of applied finish. Although final finishes such as brick veneers are cast in natural stone or form liners, and may receive a post-casting finish, they are addressed separately since the critical elements of obtaining the desired appearance are achieved during the pre-pour operation.

The depth of the applied finish should take into account the size, function, articulation and configuration of the units. Final selection of the finish gradation should be made during the mock-up phase and should include recommendations from The Shockey Precast Group. Variation of applied finishes within the individual units can be used to enhance the overall appearance of the structure. This can be a more cost-effective means of accentuating key components or areas of the façade than the use of multiple mixes. When multiple applied finishes are part of the design, the same logic regarding profile changes and/or reveal work to ensure clean breaks should be applied as that of multiple mixes.

Acid Etch Finish
Acid etching is a process that dissolves the surface cement matrix to expose the sand and, to a lesser extent, the coarse aggregate. Acid etching is typically used to achieve a light-to-medium-light exposure. The end result is similar to that of natural products such as
sandstone or limestone. The etching process leaves a sugar-cube appearance, which is enhanced by direct sunlight.

The decision to incorporate an acid-etch finish must be made prior to or during the mix design process since only acid-resistance siliceous aggregates (granite, quartz, etc.) should be used. Carbonate aggregates such as dolomite and limestone, suitable for sandblasting mixes, will dissolve or discolor through the acid-etching process due to their calcium content. Complementary aggregates (fine and coarse) and cement pigments should always be chosen when an acid etch finish is selected.

Acid etching is the crucial second-step process when the façade of the structure will include clay products such as thin brick veneer. This process not only helps remove some of the surface laitance on the brick during the manufacturing process, but also exposes the sand between the thin brick joints to mimic that of hand-laid brick mortar. It is used as a safe finish around the brick veneer for incorporated precast features such as lintels, sills, bands, and projections that have all been integrated within the same precast unit.

**Sand-Blasted Finish**

Sand blast is the generic term used for the abrasive blasting process. Varying gradations of blast material are used to chip away the precast surface. Selection of a particular gradation depends on the desired depth of finish. Sand blasting allows the designer the full range of depths obtainable in precast (light to heavy). On final exposed surfaces, brush blasting should be avoided because of its inability to uniformly remove all the surface laitance. Light blasting provides a similar appearance to that found in natural limestone without the “sugar cube” appearance created by acid etching.

In contrast to acid etching, blasting tends to be better suited to muting or camouflage minor variations that occur in the manufacturing process. This is especially true when addressing deep profile articulations. Deeper blasts have an increased ability to ensure uniformity. However, once blasting exceeds the light level of finish and texture, the end result is more dependent on the natural elements of the mix (aggregates). Complementary aggregates and matrices should always be considered when specifying deeper levels of exposure. A deeper blast can mimic other natural materials such as flamed granite and can create interesting plays of light through its texture.

Blasting can also be a more economical means of achieving multiple variations within the same unit than incorporating multiple mix designs. Blasting creates multiple variations by exposing differing levels of the coarse aggregate in pre-defined areas on each panel. The overall desired effect of texture is also influenced by the type and selection of coarse aggregate in relation to the psi of the matrix. Softer aggregates will become concave during the blasting process, while harder aggregates will become convex, depending upon the depth of exposure.

**Exposed Aggregate**

This process is achieved by chemically retarding the matrix, which provides a non-abrasive method of exposing the natural beauty of the coarse aggregates. Unlike the sandblasting process, the chemical retarder does not mute or damage the coarse aggregates. The chemical retarder is applied to the mold surface, which delays the cement paste from setting up. After stripping the panel, the retarded outer surface layer of cement is removed with a
high-pressure washer. A variety of depths, from shallow to deep, can be achieved depending on the type of retarder used. As with other finishes, variations of exposure within the same unit can be achieved with chemical retarders; however, a clear reveal or profile change is a must for the transition points to prevent bleeding of exposure. The choice of aggregate size is essential when choosing depth to prevent excessive aggregate loss “bald spots.” If the owner or designer’s vision is to enhance the bright, natural colors of the aggregates, chemical retarders should be used. It is recommended that contrasting matrices and aggregates be avoided to prevent a “patchy” appearance.

Form Liners
Form liners offer the designer a wide array of possibilities in shapes, patterns, textures, and designs. The liner material used depends on the desired effect and the number as-cast required. Any combination of applied finishes can be utilized in conjunction with form liners. Form liner finishes can be implemented either as the main aesthetic feature or as a highlight, medallion, or logo. Advances in form liner technologies have created a design palette limited only by the imagination. When vast areas of precast will use form liners, limitations of liner sizes should be incorporated with reveal work to prevent liner butt joints. Form liners provide the highest degree of texture and will enhance the play of light and shadows, creating a changing appearance of the façade throughout the day. Key placement of night illumination can also complement the effects of the liner.

Form liners are a key component when implementing a thin brick veneer. The three main types of brick liners (elastomeric, plastic grids, and snaps) each have their own positive attributes, depending on project design and panel configuration. The selection of a liner should be made with the guidance of The Shockey Precast Group. When a designer chooses to use a form liner, it is very important that the designer recognize the lead time required with form liners. Lead time will vary by type of liner and pattern selected. Liners requiring unique artwork will require additional time for the artisan to create the master mold.

Form liner lead times can range from between four to eight weeks. When elastomeric liners are used in conjunction with thin brick, a sample run of the actual brick being used is required in order to obtain the correct “fit.” The first 100 bricks from a run are measured and the form liner is based on the average brick size. In addition to the lead time for the form liner, the lead time required on the brick must be considered as well. Brick manufacturers will usually fabricate the lighter shades in the beginning of the month and the darker shades at the end (or vice versa). Depending on the time of the month and the type and color of the brick selected, it is typically four weeks minimum until the first run of bricks is delivered.

Case Studies
In this section, we feature current examples of projects that benefited from The Shockey Precast Group’s design-build capabilities. Each of these projects offered its own challenges, including aggressive schedule, complex design, tight budget, and limited site access. The use of precast concrete contributed significantly to the overall success of each of these projects.
The Calvert Street Parking Garage in historic downtown Annapolis, Maryland is a 168,000 SF parking structure owned by the Department of General Services of the State of Maryland. Design of the structure called for four bays of four levels of elevated precast framing, consisting of two ramped bays and two flat bays, providing 727 parking spaces. Exterior aesthetics were of paramount concern to the owner throughout the duration of the project given the close proximity of the new structure to several historical brick-clad buildings of the State Capitol complex. The Shockey Precast Group met this desired intent by providing a structural gray precast frame surrounded by a separate façade of architectural precast using a mix of highly articulated thin-brick and architectural precast elements. The architectural façade was essentially self-supporting with regard to gravity load, with required lateral support provided by tieback to the structural frame. In order to ensure a successful project, the design team had to be vigilant in detailing the numerous interface/offset conditions and connection schemes such that requirements for constructability and access were in concurrence with aesthetic requirements.

The Shockey Precast Group’s Winchester production facility provided 554 pieces of structural precast for the project, including double tees, beams, columns, spandrels, vertical ramp walls, shear walls, flat slabs, and stair/elevator core walls. The 223 elements of the architectural façade were provided by The Shockey Precast Group’s Fredericksburg production facility and consisted of an array of spandrels, wall panels, cornices, coping, and column covers.

The design of the façade specified two colors of thin brick to be used in either standard running or Flemish bond coursing at specific locations along the exterior elevations. Layout and detailing of the horizontal and vertical coursing of brick presented a formidable challenge to all members of the design and production team, thus requiring diligent attention to assure proper alignment of brick between precast elements. The presence of several highly articulated, ornate cornice and sill details of architectural precast presented a challenge to both design and production teams. In order to accent the precast façade, numerous pieces of decorative steel columns, channels, beams, grilles, and glazing were field-installed.
Erection of the structure was extremely difficult due to limited access to the interior footprint of the structure. The architectural façade had to be erected in conjunction with the structural components of the parking structure. The access plan was changed to eliminate ramp construction, and the last phase of construction was moved to the top of Bladen Street out of the footprint. This change saved time and expense for the general contractor, and resulted in a shorter and more continuous erection process. Erection was completed on schedule in approximately 12 weeks.

**Project Timeline:**

- **Design**
  - July 2005 – December 2005
- **Construction**
  - December 2005 – February 2007
- **Production Winchester**
  - January 9, 2006 – May 16, 2006
- **Production Fredericksburg**
  - January 3, 2006 – May 17, 2006
- **Precast Erection Start**
  - April 3, 2006
- **Erection Complete**
  - July 21, 2006
- **Open to Public**
  - January 10, 2007
This project included two parking structures that would provide 1,250 parking spaces to D.C. Nationals’ patrons. Both garages were scheduled to be built during construction of the new baseball stadium, Nationals Park. The original concept specified an underground parking garage; however, complications in the design process made this concept impractical.

With only 12 months remaining in the project schedule, the project was redesigned as a precast parking structure and The Shockey Precast Group was recruited as a design-build partner. Shockey assisted the team with development of the overall layout of the garages so that the owner’s construction completion deadline of April 2008 could be met. On-time completion was essential, as April 2008 marked the start of the 2008 baseball season and opening day of the Nationals’ new stadium.

The site itself presented significant challenges. The DC Nationals Ballpark is set below grade elevation, so it was necessary to include a retaining wall between the ballpark and the garages in the design of the parking structures. In order to meet LEED requirements, the designer had to allow for additional program features, such as bicycle parking, in the design. Parking access controls were also included to accommodate the future possibility of commercial use of the garages by the owner.

The Shockey Precast Group produced a total of 308,000 square feet of precast double tees for the project. Both garages consist of three framed levels and are three bays wide. The East garage features 170,000 square feet of double tees and the West garage includes 138,000 square feet of double tees. Design development was an ongoing process and the Shockey team’s coordination efforts included development of the drawings and matching the parking structures’ precast finishes to those of the ballpark. The Shockey Precast Group had to allow for retail and ticket sales on the first floor of both parking structures. Since these retail areas had cast-in-place concrete around them, it was necessary for The Shockey Precast Group
to include coordination and interaction with CIP in its planning and design. Because of the surrounding retail areas, the first floor of the garages was unusually tall, adding to the coordination considerations incorporated by the design team.

Complex reveals and two different sandblast patterns increased the overall intensity of the project, but the use of architectural precast made it possible for the designer’s vision to be realized well within the project timeline and budget. Another unique aspect of the project for the designer and for The Shockey Precast Group was that the precast design had to accommodate the hanging of artwork on the exterior of the garages. The precast shear walls were incorporated into the exterior “window dressing,” and a tower effect was added to the façade to create visual interest.

Erection of the parking structures began in July 2007 and was completed on November 21, 2007. The finishing of the structures was completed on March 1, 2008.

**Nationals Parking Structures Construction Timeline:**

- June 6, 2007  Production start
- July 23, 2007  Erection start
- November 21, 2007  Erection Complete
- March 1, 2008  Finishing Complete
- April 15, 2008  Walk-through with architect
The Peterson National Harbor Center is a 300-acre site located on a 1 ¼ mile waterfront stretch of the Potomac River in Prince George, Maryland. National Harbor is home to 7,000,000 square feet of restaurants, shopping, office space, residences and hotels, including the Gaylord National Harbor Resort and Convention Center. The Gaylord National Harbor Resort is the largest non-gaming hotel and convention center on the east coast and the largest hotel in Washington D.C.

A number of different parking structure configurations were considered in order to maximize the optimal number of parking spaces. The approved design specified a 247,700 SF, six-level structure to provide 1,933 parking spaces for staff and visitors to the Gaylord National Harbor Resort and Convention Center. The upper five levels of the parking structure were constructed of precast components produced by Shockey at its Fredericksburg and Winchester plants. Shockey manufactured and erected 12’ x 30” double tees with a 4” flange, 12’ x 30 ½” double tees with a 4 ½” flange, 8” flat slabs, 10” thick walls, stair units, columns with architectural finish, L-beams, 24”x36” inverted-tee beams, 10” thick prestressed spandrels with an architectural finish and 10” thick prestressed vertical ramp walls for 6’ stems.

The parking structure’s architectural precast features include horizontal ribs on spandrels and exterior elevator wall panels, column covers and a planter on the north end of the garage roof. The exterior of the parking structure required architectural mix design and finishes be consistent with those of the Hotel and Convention Center.
The use of precast rather than CIP concrete enabled the building to be constructed within its own footprint. The proposed schedule was very restrictive regarding Shockey’s activities and schedule during the construction process. The use of precast allowed the majority of the work to be performed at Shockey’s manufacturing facility, which enabled Shockey to meet the schedule’s restraints.

**Products Used:**
- 12’ x 30” DT with 4” flange
- 12’ x 30 ½” DT with 4 ½” flange
- Column Covers
- 8” precast flat slabs
- 10” thick walls
- Precast Stair Units
- Columns with Architectural Finish
- L – Beams
- 24”x36” Prestressed Inverted Tee Beam
- 10” thick prestressed spandrels with architectural finish
- 10” thick prestressed vertical ramp wall for 6’ stems
THE ALTUSGROUP
C-GRID® Reinforced Double Tees for Parking Structures

The Shockey Precast Group is a member of AltusGroup, a national partnership of precast concrete manufacturers and suppliers. Committed to innovation, AltusGroup develops and markets CarbonCast products made using C-GRID® carbon fiber grid reinforcing – including precast wall panels (architectural cladding panels and high performance insulated wall panels) pretopped double tees, and residential wall panels and stem decks. LEED-friendly CarbonCast products can weigh less, insulate better and last longer than competitive building technologies.

In 2008, Shockey embarked on its first CarbonCast project: the $7.68 million Winchester Parking Structure. The 140,000 square-foot, five-story Winchester Parking Structure is situated at a corner in Winchester’s historic district. The parking structure features a brick façade, accented with precast concrete features that mimic limestone. An enclosed, elevated pedestrian walkway will connect the parking structure with the Frederick County Office Complex. The Winchester Parking Structure features 482 precast components, including 204 precast double tees reinforced with CarbonCast C-GRID® carbon fiber. The use of C-GRID® reinforced double tees provided a cost-effective solution that enabled the project to stay within budget, while the use of precast concrete enabled the team to meet the owner’s very aggressive schedule. The Shockey Precast Group’s other C-GRID® projects include parking structures for The University of Maryland at Shady Grove and Walter Reed Medical Center.

Shockey’s membership in the AltusGroup enables us to bring knowledge of and experience with the industry’s latest innovations and technology to every one of our parking structure projects. Not only can we offer economic, attractive parking structure solutions, we also use materials and systems that can result in greater parking structure longevity, durability, and overall strength.

The Shockey Precast Group’s C-GRID® Embedment Machine places C-GRID® into a double tee for the Winchester Parking Structure project.
What Are CarbonCast® Pretopped Double Tees?

A Lower Cost, Faster, Better-Performing System.
If you've ever swung a carbon fiber tennis racket or golf club, you know how much stronger and lighter carbon fiber is than other materials. Now CarbonCast combines this cutting edge technology with best practices in precast concrete to create CarbonCast.

CarbonCast Pretopped Double Tees use carbon fiber to do the secondary reinforcing job that once belonged to steel mesh. The patented, 1-mm-thick, high strength C-GRID® directional reinforcement is placed near the surface of the tee, thereby dramatically reducing opportunities for cracks in the concrete. With tight spacing between reinforcing strips, the grid also acts as a crack stopper, so that any cracks that may occur stay small and do not propagate. In the stems of CarbonCast tees are the same prestressed steel strands maintaining camber and resisting the loads with 31,000 lbs. of force per strand.

CarbonCast Double Tees can be made flat or warped to work with field-installed precast curbs to direct water to drains, or they can be cast to receive field-applied washes/pourstrips. CarbonCast Double Tees with precast curbs and welded end connections for seismic performance are recommended in areas where deicers and chloride-laden water is found. Curbed decks reduce or eliminate field-applied washes which are subject to cracking and the adverse effects of corrosion including leaks, spalling, and rusting of diaphragm reinforcing which can stain vehicles and decks, and require constant maintenance.

### System Overview

<table>
<thead>
<tr>
<th>CarbonCast Double Tee</th>
<th>CarbonCast Tee Installation</th>
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<tbody>
<tr>
<td>Primary reinforcing</td>
<td>Steel stand</td>
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<td>Carbon fiber grid</td>
<td>A. Welded Stainless steel connectors</td>
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<td>Concrete strength</td>
<td>6,000 psi Drainage</td>
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<td></td>
<td>Cast (warped) tees</td>
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<td></td>
<td>Curbs</td>
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<td>Field-topped girders</td>
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<td></td>
<td>Field-cast washes</td>
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### Features and Benefits

- **Eliminates corrosion**
  - No staining or spalling
  - No sealer required
  - Reduces maintenance—eliminates resealing

- **Minimizes cracks and crack propagation**
  - Tees look better, last longer

- **High strength/low permeability concrete**
  - Inhibits water absorption

- **Stainless steel connections**
  - Controls corrosion

- **Welded installation**
  - Meets seismic requirements
  - Reduces trades on site
  - Accelerates schedule
  - Lower cost than current (pourstrip) systems

- **Lighter weight**
  - Less embedded energy/reduced CO2 footprint

- **Full-length flange thickness**
  - Reduced vulnerability to tension cracking during shipping, handling

- **Sustainable**
  - Significant contributions to LEED® certification
Why CarbonCast® Pretopped Double Tees and Curbed Decks?

**Lower Initial Cost.**
CarbonCast Pretopped Double Tees can save contractors money when installed with welded connections because fewer pourstrips are used—even in high seismic zones—and no sealer is required.

With conventional tees, general contractors can pay for pourstrips to meet seismic requirements and sealer to protect steel mesh from corrosion. Pourstrips have become even more costly now that the 2008 ACI 362 durability standard is in effect, requiring more concrete cover.

A less expensive way to make a seismic diaphragm is to weld stainless steel double tee connections. This proven technique achieves seismic performance for roughly less than half the cost of pourstrips. And with C-GRID® carbon fiber reinforcement, it's OK to omit expensive sealers—CarbonCast Pretopped Double Tees don't need sealers because carbon fiber doesn't rust!

With pourstrips and sealer eliminated, and fewer trades involved or involved for less time, CarbonCast Pretopped Double Tees help you speed up project completion and save while giving the customer a better product.

**Better Performance.**
All precast double tees use reinforcing mesh in the flange to hold concrete together if it cracks, and to transfer floor loads to the stems. But the unique design of C-GRID carbon fiber reinforcement controls cracking better, keeping them smaller and preventing propagation. Since CarbonCast Pretopped Double Tee flanges are unaffected by chlorides, they won't crack, stain, or swell due to rusting and expanding reinforcement in the flange or “corrosion zone.”

The new ACI 362 code requires significantly more concrete coverage of steel in pourstrips. It makes them costlier, steeper or wider. Sealer will also be required on all precast tees to protect steel-mesh secondary reinforcing. Stainless steel reinforcing in may be used as an option in pourstrips, but again at significant cost. However, carbon fiber-reinforced tees were not contemplated by the ACI 362 code committee. Adding sealer to a CarbonCast Pretopped Double Tee is an unnecessary additional expense.

**And Lower Life-Cycle Cost.**
Long-term maintenance of CarbonCast Pretopped Double Tees is also less costly because resealing is not required, there are fewer caulk joints to repair or replace, and C-GRID reinforced, high strength concrete should not crack or spall due to corrosion—so occasional patching of tees is also eliminated.

These sections have been reprinted with permission from the Altus Group's Carbon Cast Pretopped Precast Double Tees brochure.
Washington DC Nationals Parking Structures, Washington, DC
SECTION 03 41 00  
PRECAST STRUCTURAL CONCRETE  

SHOCKEY  
THE PARTNER OF CHOICE®  
The Shockey Precast Group  
GUIDE SPECIFICATION  

General  

1.1 SUMMARY  
A. Section includes:  
1. Structural precast concrete for:  
   a. Columns  
   b. Beams  
   c. Spandrels  
   d. Floor and Roof Double Tees  
   e. Inverted Tee Beam  
   f. Stair Riser Sections  
   g. Wall Panels  
   h. Flat Slabs  
   i. Shear Walls  
2. Caulking and Expansion Joints  
3. Accessories and Supporting Devices  

B. Related Requirements:  
1. Section 03 45 00 - Precast Architectural Concrete  
2. Section 07 92 01 – Joint Sealants  

1.2 REFERENCES  
A. American Concrete Institute:  
1. ACI 301 - Specifications for Structural Concrete  
2. ACI 318 - Building Code Requirements for Structural Concrete  

B. ASTM International:  
1. ASTM C 33 – Standard Specification for Concrete Aggregates  
2. ASTM A 36/A 36M - Standard Specification for Carbon Structural Steel  
5. ASTM C 150 - Standard Specification for Portland Cement
6. ASTM A 153/A 153M - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
7. ASTM A 185 - Standard Specification for Steel Welded Wire Fabric, Plain, for Concrete Reinforcement
9. ASTM A 416/A 416M - Standard Specification for Steel Strand, Uncoated Seven-Wire for Prestressed Concrete
10. ASTM C 494 – Standard Specification for Chemical Admixtures for Concrete
11. ASTM A 497 - Standard Specification for Steel Welded Wire Fabric, Deformed, for Concrete Reinforcement
12. ASTM A 615 – Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement
13. ASTM C 618 – Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Portland Cement Concrete
14. ASTM A 666 - Standard Specification for Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar
15. ASTM A 706/A 706M - Standard Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement
16. ASTM C 979 – Standard Specification for Pigments for Integrally Colored Concrete
17. ASTM C 989 – Standard Specification for Ground Granulated Blast-Furnace Slag for Use in Concrete and Mortars
18. ASTM F1554 – Grade 36 Anchor Bolts

C. American Welding Society:
1. AWS D1.1 - Structural Welding Code - Steel
2. AWS D1.4 - Structural Welding Code - Reinforcing Steel
3. AWS D1.6 – Structural Welding Code – Stainless Steel

D. Precast/Prestressed Concrete Institute:
1. PCI MNL-116 - Manual for Quality Control for Plants and Production of Structural Precast Concrete Products
2. PCI MNL-120 - PCI Design Handbook - Precast and Prestressed Concrete
3. PCI MNL-123 - Design and Typical Details of Connections for Precast and Prestressed Concrete
5. PCI MNL 135 – Tolerances for Precast and Prestressed Concrete Construction
1.3 DEFINITIONS

A. Fabrication Drawings: Documents used by the production facility to manufacture the precast components. Sometimes referred to as “Shop Drawings.” Information included:
   1. Required dimensional information
   2. Description and location on all inserts, bearing plates, anchors and reinforcement materials required to manufacture, transport, and erect the precast component
   3. Finish requirements for each component
   4. Handling, storage and shipping instructions
   5. Provided as an informational submittal only

B. Erection Drawings: Documents providing the assembly placement of precast components on the job site. Erection Drawings are reviewed and sealed by a Professional Engineer. Information included:
   1. Plans and elevations locating and dimensioning all precast components. Each precast component is individually identified.
   2. Sections and details showing connections, openings, blockouts, and cast-in items and their relationship to the structure.
   3. Description of all loose and cast-in hardware for making connections.

C. Construction Plan: A management plan for the sequence of assembly of the precast components of the project. This plan includes:
   1. Access plan for crane and transport of precast components.
   2. Erection sequence by loads being shipped.
   3. Erection block plan outlining the sequence of erection activity.
   4. Specific erection criteria required for the particular project.
   5. Project-specific construction stability plan that outlines any additional erection bracing that may be required.
   6. Technical data sheet on grout used for the project.
   7. Erection tolerances for the project.

D. Field-Use Erection Drawings: The erection drawings with any modifications made during the approval process that are distributed prior to actual erection of the project.

E. Control Number: A unique identification of each precast component for a project.

F. Piece Mark: A component identification of a precast element on a project. Similar pieces can have the same Piece Mark but each will have a unique Control Number.

G. CIP: Cast-in-Place Concrete

H. Architectural Features: Where final appearance or form of precast components require the use of colored aggregate, pigmented concrete mix or surface textures such as sandblasting, water wash, etched finishes or thin brick.
I. **BIF:** “Bottom in form” indicates the surface of precast that will be in the bottom of the form during casting.

J. **SIF:** “Side in form” indicates the surface of the precast that will be in the side of the form during casting by built-up rails.

K. **TIF:** “Top in form” indicates the top exposed surface during casting.

### 1.4 ADMINISTRATIVE REQUIREMENTS

A. **Coordination**

1. Coordinate the Work of framing components not pre-tensioned but associated with the Work of this section.
2. Coordinate cutting, drilling or coring in precast members with the manufacturer.
3. Coordinate all precast opening or penetration greater than 10 inches in any dimension with the manufacturer prior to submittal of Erection Drawings.

B. **Pre-installation meetings**

1. Convene minimum one week prior to commencing the onsite work of this section.
2. Coordinate the sequence of installation with foundation and supporting elements in place with precast items to be delivered.

C. **Site Survey:** Provide a site survey to verify field dimensions and tolerances a minimum of 2 weeks prior to delivery of precast units for installation.

### 1.5 SUBMITTALS

A. **Action Submittals:** Provide for review and approval.

1. **Erection Drawings:** Indicate layout, unit locations, unit identification marks, connection details, dimensions, openings, and relationship to adjacent materials and conformance with the requirements of the Contract Documents and sealed by professional engineer. Provide coordination information for items required to be embedded in adjacent materials.
2. **Design Calculations:** Submit design data reports indicating calculations for loadings and stresses of fabricated precast components, connections, and reinforcement. Calculations shall be prepared by Professional Engineer experienced in precast concrete design.
3. **Samples:** Submit three samples 12 x12 inch (304.8 x 304.8 mm) in size illustrating surface finish treatment of architectural featured component.
4. **Mockup:** Provide access to a mockup panel at the precast manufacturing plant for approval by the Architect for color and texture. The approved mockup shall be the control standard for color and texture.

B. **Informational Submittals**

1. **Mix Design:** Provide the concrete design mix with certification regarding compliance with requirements of the Contract Documents.
2. **Field Use Erection Drawings:** Submit field use erection drawings incorporating comments from approved Erection Drawings.
3. Construction Plan: Submit prior to the pre-installation meeting, a construction plan, including calculations and details for guying, staying and shoring precast elements to assure structural stability during the erection phase. Provide for the removal, replacement, and relocation of guying, bracing and shoring required until all permanent structural connections are completed.

C. Closeout Submittals
   1. Provide Manufacturer’s Warranty letter.

1.6 QUALITY ASSURANCE

A. Perform Work in accordance with requirements of PCI MNL-116, PCI MNL-123, PCI MNL-120, PCI MNL 135.

B. Fire Rated Construction: Rating as indicated by construction type on contract documents.

C. Source Quality Performance Testing: Provide for tests for all precast concrete work in conformance with PCI Plant Certification requirements. Use certified test equipment, and unless otherwise specified, conform with:
   1. Manual For Quality Control For Plants and Production of Precast and Prestressed Concrete Products, PCI MNL-116 (latest edition)
   3. ACI 318 for the Building Code Requirements for Reinforced Concrete (latest edition)

D. Mockup Control Sample Unit: Provide a mock up panel at the plant, 4 feet by 4 feet in size, for quality comparison of finished unit to an approved appearance sample for color and texture.

E. The plant quality control records and inspection procedures for this project shall be available for review, verification and in-plant inspection by an independent testing agent or the Architect/Engineer.

1.7 QUALIFICATIONS

A. Fabricator: Company certified by the Prestressed Concrete Institute (PCI) Plant Certification Program with an in-house engineering department managed by a registered professional engineer.

B. Precast Engineer: Design precast concrete members under direct supervision of Professional Engineer experienced in precast design and licensed in the state of the project.

C. Erector: Company with experience in the erection of precast units similar to those required for this project and shall be a Qualified or Certified Erector under the PCI Field Certification Program.

D. Welder: Qualified in accordance with AWS D1.1, AWS D1.4, and AWS D1.6
1.8 DELIVERY, STORAGE, AND HANDLING

A. Lift and support precast concrete members during manufacturing, yarding, transporting and erection operations only from identified support points with suitable lifting and handling devices.

B. Lifting inserts will have a minimum safety factor of 4. Reusable lifting hardware and rigging will have a minimum safety factor of 5.

C. Lifting or Handling Devices: Capable of supporting member in positions anticipated during manufacture, storage, transportation, and erection.

D. Storage:
   1. Protect members to prevent staining, chipping, or spalling of concrete. Store members off the ground on dunnage materials as recommended by fabricator.
   2. Place all units so that identification marks are readable.
   3. Stack so that lifting devices are accessible and undamaged.

E. Mark each member with date of production, job number, control number, and piece mark referenced from Erection Drawings.

1.9 WARRANTY

A. Provide Manufacturer’s Warranty for a 1-year period.

PRODUCTS

2.1 FABRICATORS

A. Fabricators:

2.2 DESIGN REQUIREMENTS

A. General: The project, as shown on the drawings, including component dimensions and connection configurations, provides the requirements for the development of the design documents. Design shall include consideration for customary stresses incurred in factory precasting, transporting, and erecting. The design, manufacturing, transportation and erection process shall be compatible with the requirements of the Contract Documents.

B. Design Criteria:
   1. Design all ledges, haunches, bearing areas, and connections as recommended in PCI Design Handbook. Haunches, dapped end bearings and connections without redundant means of load transfer are considered critical.
   2. Minimum reinforcing for all precast prestressed concrete and precast reinforced concrete shall be in accordance with ACI 318. Analysis of prestressed components will include a check of the shear reinforcing requirements at .1L, .2L, .25L and .3L, where L is the component length.
C. **Modifications:** Submit all proposed modifications to the project designs represented on the drawings with complete design calculations and drawings, prepared and signed by a licensed professional engineer for review and approval.

D. **Maximum Allowable Deflection:** Per ACI 318-9.5 - Control of Deflections

E. **Seismic Design:** Design and detail elements and connections to resist seismic force in accordance with code requirements and ACI 318 for the following:

1. As specified by contract documents.

F. Design members exposed to weather to allow movement of components without damage, failure of joint seals, undue stress on fasteners or other detrimental effects, when subject to seasonal or cyclic day/night temperature ranges.

G. Design system to accommodate construction tolerances, deflection of other building structural members and clearances of intended openings.

H. **Calculate structural properties of framing members in accordance with ACI 318.**

2.3 **MATERIALS**

A. **Concrete Materials:** As appropriate to design requirements and PCI MNL-116.

1. Cement: Gray Portland, conforming to ASTM C 150 Type I or III.
2. Cement: White Portland, conforming to ASTM C150 Type I (for architectural mixes).
3. Fly Ash Admixture: ASTM C 618 Class C or F -- 25% maximum.
4. Ground Granulated Blast-Furnace Slag: ASTM C 989 Grade 100 or 120 – 40% maximum.
5. Aggregates: ASTM C 33 except as modified by PCI MNL 116.
6. Air-entraining admixtures: ASTM C 260

B. **Concrete Mix Design:** ACI 318, Chapter 5, using standard deviation calculations in accordance with section 5.3.1.1 or 5.3.1.2.

1. The concrete mix designs will conform to the following requirements:

   Structural concrete: Columns, Walls, Stairs, Spandrel Beams
   - Strength of Concrete – 5000 psi minimum
   - Water-cementitious materials ratio – maximum 0.42
   - Air Content – 5.5% +/- 1.5%

   Structural concrete: Double Tees, Beams
   - Strength of Concrete – 6000 psi minimum
   - Water-cementitious materials ratio – maximum 0.40
   - Air content – 5.5% +/- 1.5%

   Self-Consolidating Concrete (SCC)
   - Strength of Concrete – 6000 psi minimum
   - Water-cementitious materials ratio – maximum 0.38
   - Air content – 5.5% +/- 1.5%
Architectural concrete:
- Strength of Concrete – 5000 psi minimum
- Water-cementitious materials ratio – maximum 0.44
- Air content – 5.5% +/- 1.5%

C. Batching concrete:
1. The concrete batching plant will be in conformance with ASTM C 94 and will be certified by the National Ready Mixed Concrete Association. Volumetric batching of concrete will not be permitted. All measurements of the various components will be by weight and will be accurate (within the most recent tolerance limits of ASTM C 94).
2. The use of calcium chloride or admixtures containing chloride ions or other salts is not more than 0.15% chloride ions or other salts by weight of admixture.

2.4 REINFORCING AND CONNECTION MATERIALS

A. General: Provide all reinforcement, accessory and connection materials required for a complete installation as indicated on the approved drawings. Pour strip reinforcement to be supplied and installed by others unless specified. Provide Grouting as required for design bearing.

B. Reinforcing Bars: ASTM A 615, Grade 60. Reinforcing used to fabricate embedded parts or connections by welding will be ASTM A 706.

C. Welded anchor studs: AWS D1.1

D. Prestressing Strand: ASTM A 416, 270,000 psi minimum ultimate strength, uncoated, 7-wire, low relaxation.

E. Anchor Bolts: ASTM F 1554 Grade 36

F. Welded Wire Fabric: ASTM A 185 (plain steel) or ASTM A 497 (deformed steel); in flat sheets; unfinished

G. Carbon Fiber Reinforcement: C-GRID® as manufactured by Chomarat

H. Tensioning Steel Tendons: ASTM A 416/A 416M Grade 270K of sufficient strength commensurate with member design.

I. Rod Anchor bars: Dayton/Superior High Strength Coil Rod, or approved equal.

J. Supports for Reinforcement for Exposed-to-View Concrete: CRSI Class 1, plastic protected legs

2.5 ACCESSORIES

A. Connecting and Supporting Devices:
1. ASTM A 36/A 36M carbon steel, Plates, angles, items cast into concrete [or] [items connected to steel framing members,] inserts conforming to PCI MNL-123; hot-dip galvanized in accordance with ASTM A 153/A 153M. Surfaces requiring field welding shall be ZRC painted.
2. ASTM A 666 Type 201 LN, 302 or 304 stainless steel, Tee-to-Tee flange connections conforming to PCI MNL-123.
3. Anchor Bolts: ASTM F 1554 Grade 36

B. Grout: Non-shrink, non-staining, minimum yield strength of 5,000 psi at 28 days.

C. Bearing Pads:
1. Standard Bearing Pad: Rubber pad composed of homogeneous blend of ozone-resistant rubber elastomer and high strength random synthetic fiber cords; Surface hardness of 75 Shore A durometer +/- 5 percent; Compression, 8000 psi; MASTICORD as manufactured by JVI Inc. or approved equal.
2. Laminated Fabric-rubber Pads: Preformed, unused synthetic fibers and new unvulcanized rubber. Surface hardness of 80 Shore A durometer +/- 10% (Capralon or approved equal).
3. Expansion Bearing Pads: Assemblies consisting of lower and upper components. Dynalon or approved equal.
   a. The upper component: An assembly of a sheet of stainless (14 gage minimum) with a minimum 2B mill finish. Sized larger than the lower element by a minimum of 1/2 inch in each direction.
   b. The lower element: An assembly of a Standard Bearing pad, with a stainless steel support plate and a bonded contact layer of PTFE (Teflon).

D. Shims: Steel, ASTM A 36; or engineered multipolymer plastic material, compressive strength of 8000 psi; Korolath, or an approved equal.

E. Mechanical Splice for Future Expansion Column and Wall Reinforcing Anchorage: Erico Lenton or NMB Splice Sleeve.

F. Double Tee Flange-to-Flange Shear Connectors: JVI Vector Connector, or approved equal, manufactured from ASTM A 666 Type 201LN or 304L stainless steel, or, where stainless steel is not required, ASTM A 36 steel with J-Finish corrosion protection.

G. Bolts, Nuts and Washers: ASTM A 307 High-strength steel type recommended for structural steel joints; Corrosion resistant chromium-nickel type.

H. Prime Paint: (ZRC) Zinc rich alkyd type coating.

2.6 FABRICATION

A. Fabrication procedure to conform to PCI MNL-116 and ACI 318.

B. Maintain plant records and quality control program during production of precast members. Make records available upon request.

C. Ensure reinforcing steel, anchors, inserts, plates, angles, and other cast-in items are embedded and located as indicated on erection drawings. Clean surfaces of all embedded items of rust, scale, grease, and foreign matter.

D. Hardware supplied by other trades shall be furnished to the fabricator fully assembled and tagged for location a minimum of 30 days prior to scheduled production.
E. Fabricate required openings with dimension larger than 10 inches (250 mm) in diameter or larger for rectangular openings as shown and approved on erection drawings. Provide openings in Tee stems for running electrical conduit as coordinated with approved shop drawings; and embed accessories provided by other Sections, at indicated locations.

F. Tension reinforcement tendons as required to achieve design load criteria.

G. Ends at Stressing Tendons: Coat the exposed ends of prestressing strands in all prestressed members with a bitumastic coating; Sonneborn Hydrocide 700 or approved equal. Recess exterior exposed to view ends of tendons and patch to match surrounding surface.

H. Weld steel fabrications in accordance with AWS D1.1. Weld reinforcing steel in accordance with AWS D1.4. Welding processes shall not reduce the cross-sectional area of the concrete reinforcement. Do not tack weld reinforcing. Paint all field welds with ZRC.

I. Mark each piece of precast concrete for identification and record the date of casting. Marks will be placed so the final appearance of the product is not impaired.

J. Provide free access by the Architect/Engineer to all parts of the manufacturing facility.

K. Minor patching in plant is acceptable, providing structural adequacy and appearance of units is not impaired.

2.7 FINISHES

A. Finish exposed-to-view architectural finish surfaces of precast concrete members to be uniform in color and appearance.

B. Cure members under similar conditions to develop required concrete quality, and minimize appearance blemishes including non-uniformity, staining, or surface cracking.

C. Patching where required, shall be accomplished by skilled craftsmen in such a manner that the structural adequacy is maintained and the appearance and durability are not impaired.

D. Provide finishes as indicated on the finishes schedule listed below.

Double Tees

1. Tee areas of CIP concrete topping: Top surface shall be transverse raked to 0.25" depth minimum to insure bond of topping
2. Tee areas without CIP concrete topping: Top surface shall receive rough horizontal broom or swirl broom finish that shall not exceed a depth of 0.25"
3. SIF, BIF and edges: Standard form finish
4. Depressor holes: Shall be filled with non-shrink, non-staining grout to match surrounding surfaces
Inverted T-Beams

1. Top surfaces to receive CIP topping: Top surface shall be transverse raked to 0.25” depth minimum to insure bond of topping
2. Top surfaces not receiving CIP topping: Top surface shall receive rough broom finish that shall not exceed a depth of 0.25” and that shall be perpendicular to the length of the beam
3. SIF, BIF and edges: Standard form finish

Columns

1. For non-architecturally finished columns: SIF and BIF shall be standard form finish. TIF finish shall be steel trowel
2. For architecturally finished columns: SIF and BIF surfaces shall receive finish as prescribed by approved architectural sample. TIF finish shall be steel trowel

Spandrels

1. TIF surface: Shall receive a light broom finish that shall not exceed a depth of 0.125” and that shall run perpendicular to the length of the spandrel
2. SIF and BIF surfaces: Standard form finish
3. For spandrels that require architectural finish: SIF and BIF will receive finish as prescribed by approved architectural sample

Walls

1. TIF surface: Shall receive a light broom finish not to exceed a depth of 0.125” or a steel trowel finish
2. SIF and BIF surfaces: Standard form finish
3. For walls that require architectural finish: SIF (where required) and BIF will receive finish as prescribed by approved architectural sample

Stairs

1. Top surface in final construction: Rough broom finish not to exceed a depth of 0.25” or sandblast finish to provide non-slip surface
2. SIF and BIF surfaces: Standard form finish

Flat Slabs

1. Flat slab areas of CIP concrete topping: Top surface shall be transverse raked to 0.25” depth minimum to insure bond of topping
2. Flat slab areas without CIP concrete topping: Top surface shall receive rough broom finish that shall not exceed a depth of 0.25”
3. SIF and BIF surfaces: Standard form finish

2.8 FABRICATION TOLERANCES

A. Conform to PCI MNL-135
   1. Exception: Double tee lengths +1/4 inches/- 3/4 inches

2.9 SOURCE QUALITY CONTROL AND TESTS

A. Test and analyze concrete in accordance with PCI MNL-116.
EXECUTION

3.1 EXAMINATION

A. A minimum of 2 weeks prior to scheduled delivery of precast materials, verify supporting work and site conditions are ready to receive work and field measurements are as indicated on field use erection drawings.

B. General Contractor shall provide to fabricator verification that supporting structure has met or exceeded the design requirements of the precast system design as required by PCI guidelines and Contract Documents. Support requirements shall include but not be limited to:
   1. Field Placed Bearing Walls or Footings: Provide true level bearing surfaces with elevations of +/- 1/2 inch unless shown otherwise on the Drawings.
   2. Accurate placement and alignment of anchor bolts, plates, or dowels in CIP column footings, beams, wall footings, and other field placed supporting elements.
   3. CIP Concrete supporting structure has met design strength requirements as specified.

3.2 PREPARATION

A. Prepare support equipment for erection procedure.

3.3 ERECTION

A. Install and secure precast units as shown on the Contract Documents and as indicated by the field erection drawings in conformance with PCI – MNL 127.

B. Erect members without damage to structural capacity, shape, or finish. Replace or repair damaged members.

C. Align and maintain uniform horizontal and vertical joints, as erection progresses.

D. Maintain temporary bracing in place until final support is provided.

E. Provide temporary lateral support to prevent bowing, twisting, or warping of members.

F. Adjust differential camber between precast members to tolerance before final attachment.

G. Secure units in place. Perform welding in accordance with AWS D1.1, and AWS D1.6 for stainless.

3.4 ERECTION TOLERANCES

A. Erect members level and plumb within allowable tolerances.

B. Conform to PCI MNL-135 and PCI MNL 127 – Tolerances for Precast and Prestressed Concrete Construction.

C. When members cannot be adjusted to conform to design or tolerance criteria, consult with Architect/Engineer. Execute modifications as directed by Architect/Engineer.
3.5 FIELD QUALITY CONTROL

A. Welding: Inspect welds in accordance with AWS D1.1, AWS D1.4, and AWS D1.6 as appropriate.

3.6 PROTECTION OF INSTALLED CONSTRUCTION

A. Protect members from damage caused by field welding or erection operations.

B. Use non-combustible shields during welding operations to protect adjacent Work.

3.7 CLEANING

A. Clean weld marks, dirt, or blemishes from surface of exposed members.

B. Remove all debris and surplus materials associated with this scope of work from the premises.
Shady Grove Metro Station Parking Structure, Gaithersburg, MD
GLOSSARY

A

Abrasive nosing - a non-skid metal unit which is cast into the nose of a precast stair panel.

Addendum - a supplement to specifications or contract drawings issued prior to the execution of the construction contract.

Admixture - a material other than water, aggregates, and cement used as an ingredient of concrete or grout to impart special characteristics.

Admixture, air entraining – a material added to the concrete for the purpose of entraining minute bubbles of air in the concrete during mixing and thus improving the durability of concrete exposed to cyclical freezing and thawing in the presence of moisture.

A frame – an A-Shaped frame used to support panels on flat bed trucks during shipping.

Aggregate – natural occurring, processed or manufactured inorganic particles which are mixed with Portland cement and water to produce concrete; normally comprises 60 to 80 percent of the total volume of concrete.

Aircraft cable – multi-strand steel cable, in loop form, cast in precast panels for handling purposes; cable is more flexible than prestressing strand.

Air entrainment – an increase in the amount of air in a concrete mix through the use of an air-entraining admixture (see admixture, air entraining); air entrained concrete displays increased workability and cohesiveness.

Air pocket – pits (entrapped air or water bubbles) in the form faces of a panel caused by improper consolidation or inadequate draft.

Alignment face – face of a wall panel which is to be set in alignment with the face of adjacent panels.

Anchor – (1) headed studs, deformed studs, straps, rebar, etc. welded to steel angels or plates and embedded in concrete for use as part of a connection (2) any item cast into or pre-attached to the structure for the purpose of receiving a connection.

Approval – acceptance of the Precaster's drawings by the Architect, Engineer of Record, and General Contractor indicating that all building conditions and dimensions shown are correct and final.

Architectural precast concrete – any precast concrete unit of special or occasionally standard shape that through application or finish, shape, color, or texture contributes to the architectural form and finished effect of the structure; units may be structural or decorative, and may be conventionally reinforced or prestressed.

Assembly – a set of parts arranged into one unit.

B

Backup material – material used to limit the depth of the sealant in panel joints.

Backup mix – the concrete cast into the mold as a filler behind a thin layer of the more expensive face mix.

Bagtie – thin gage wire ties (generally No. 16, 15, or 14 gage) used to fasten reinforcing bars together at intersections.

Bar chair – a non-corrosive, rigid device used to support and/or hold reinforcing bars at a given distance from the form face before and during concreting.

Base plate – a steel plate anchored to the bottom of a precast unit for the purpose of fastening it to the foundation.

Batch – the amount of concrete produced in one mixing operation.

Beam pocket – opening in a vertical member in which a beam is to rest.
Bearing area - the surface in square inches which comes into contact with a vertical load transferring member.

Bearing pad – a pad, usually neoprene, which is placed between a member and its support.

Bearing plate – a steel- or Teflon-coated plate placed between a member and its support.

Bill of materials – material list for individual project

Bleed hole – a hold in a plate or angle which is provided solely to release entrapped air or water during concrete placing operation.

Bleeding – a form of segregation in which some of the water in a mix rises to the surface of freshly placed concrete; also know as water gain.

Blocking – the shims required to level and/or plumb a unit in its proper position.

Blockout – to form a hole, or reduce the height or width of a panel by affixing material to the form (space within a form in which concrete is not to be placed).

Bond breaker – a substance placed on a material to prevent it from bonding to the concrete, or between a face material such as natural stone and concrete backup.

Bowling – the deflection of a vertical panel in a single plane.

Bulkhead – a vertical partition in the form blocking fresh concrete from a section of the form; divides a continuous casting bed into given unit lengths.

Bundling – placing several parallel elements of reinforcement in contract with each other.

Camber – (1) the upward deflection which occurs in prestressed concrete elements due to the net bending resulting from stressing forces and self-weight. It specifically does not include dimensional inaccuracies due to errors in manufacture, improper bearings, or other deficiencies in construction; (2) a built-in upward curvature in some forms for precast concrete, other than prestressed, to avoid deflection under load to below a defined line of finished product.

Cast – to place concrete (in plastic state) into a form.

Cast-in – cat integrally with a concrete unit; not stabbed in after casting.

Cast-in-place – concrete which is placed in the field.

Cast stone – precast concrete whose finish resembles that of cut or polished stone.

Caulking – an elastomeric sealant used to fill panel joints thus sealing a building from the elements.

Chamfer – a beveled corner or edge which is formed in concrete work by placing a three-cornered piece of wood (cant strip or skew back) in the form corner.

Chamfer strip – triangular or curved insert placed inside corner of form to produce rounded or beveled corner; also called fillet, cant strip, skew back.

Clearance – the distance between two surfaced.

Clear span – the distance between the inside edges of the bearing surfaces of two supporting members.

Cold Joint – a joint necessitated by several casting stages but designed and executed to allow the separate components to appear and perform as one homogeneous unit; term only applies when the first casting is allowed to harden prior to placing the second.

Column – an element used primarily to support axial compressive loads and with a
height at least three times its smallest lateral dimension.

Column cover – a precast panel which covers one or more sides of a column which would otherwise be exposed.

Composite construction – a type of construction wherein the floor slab is fastened to the beams in such a manner that they act together as a more efficient member in carrying live loads.

Concrete – a mixture of portland cement, fine aggregate, coarse aggregate, and water.

Concrete, structural lightweight – concrete that has a 28-day compressive strength in excess of 2,500 PSI and an air-dry unit weight of less than 115 PCF; a lightweight concrete without natural sand is termed all-lightweight concrete and lightweight concrete in which all fine aggregate consists of normal weight sand is termed sand-lightweight concrete.

Concrete cover – the clear distance from the face of the concrete to the reinforcing steel.

Consolidation – the use of hand tools, vibrators, or finishing machines during the casting process to eliminate voids, other than entrained air, and to provide a dense concrete, good bond with reinforcement, and a smooth surface.

Coping – a panel which forms the top of a wall and seals it form the elements.

Corbel – steel or reinforced concrete bracket which protrudes from a column or wall panel to provide support for another member or take support from an adjacent part of structure.

Cornice – panel which fits under a ceiling or projecting roof.

Curtain wall – precast wall panels which when in place may form window frames and interior/exterior wall construction, but support no loads from building.

Deflection – the distance a structural member moves from its normal position when subjected to a load.

Draft – the slope of concrete surface in relation to the direction in which the precast element is withdrawn from the mold; it is provided to facilitate stripping with a minimum of mold breakdown.

Drip – a projecting fin or groove at the outer edge of a sill, projecting horizontal wall element or soffit, designed to interrupt the flow of rainwater downward over the wall or inward across the soffit; drips are normally used only on units having smooth or lightly exposed finish.

Elongation – in prestressed work, the difference between a strand’s initial length and its length after stressing.

Engineer of record - engineer who creates original building design and is responsible for the design.

Erection – the placing of precast units into their respective positions in the structure.

Expansion bolt or anchor – an expandable device made of metal inserted into a drilled hole in hardened concrete that grips concrete by wedging action when the nut or head is rotated.

Fabrication – actual work on reinforcing bars or hardware such as cutting, bending, and assembly.

Face – the surface of a panel.

Face mix – the concrete at the exposed face of a concrete unit; used for specific appearance reasons.

False joint – scoring on the face of a precast unit; used for aesthetic or weathering purposes and normally made to stimulate an actual joint.
Fascia – the outside horizontal panel on the edge of a roof or overhang.

Fenestration – the design and placing of windows in a building.

Finish - treatment or texture given to concrete surfaces.

Form – a temporary receptacle which receives concrete and dictates a unit’s shape. It can be made of wood or steel, but requires not pattern or positive.

Form liner – molded sheet which when affixed to a form gives the panel a special finish treatment; liners are made of rubber, plastic, wood, etc.

Form release agent – a substance applied to the forms for the purpose of preventing bond between the form and the concrete cast in it.

Galvanize- to coat with rust resistant zinc by spraying, dipping, or electrolytic disposition.

Gradation – the sizing of granular materials. For concrete materials, usually expressed in terms of cumulative percentages larger or smaller than each of a series of sieve openings or the percentages between certain ranges of sieve openings.

Grout – a mortar type mixture which is hand packed or applied under pressure in such a consistency as to ensure complete filling of all voids. The usual proportions of a grout mix are one (1) part of cement to three (3) parts of well-graded sand by weight with water content adjusted so that a mass of grout squeezed in the hand remains its shape.

Hardware – a collective term applied to items used in connecting precast units or attaching or accommodating adjacent materials or equipment. Hardware is normally divided into three categories:

- Contractor’s Hardware – items to be placed on or in the structure in order to receive the precast concrete units: e.g., anchor bolts, angels, or plates with suitable anchors.
- Plant Hardware – items to be embedded in the concrete units themselves, either for connections and precast erector’s work, or for other trades, such as mechanical, plumbing, glazing, miscellaneous iron, masonry, or roofing trades.
- Erection Hardware – all loose hardware necessary for the installation of the precast concrete units.

Honeycomb – a coarse stony concrete surface with voids lacking in fines; some probable causes are congested reinforcement, narrow section, insufficient fines, loss of mortar, and inadequate consolidation.

Insert – a connecting or handling device cast into precast units. Inserts are machine or coil-threaded to receive a bolt or slotted to receive a bolt head.

Joint – The space between two adjacent erected panels.

Key – a continuous or semi-continuous slot in concrete to receive grout, leveling blocks, or dowels.

Lifting device – an assembly used in handling or erection of precast panels.

Lift point – predetermined points from which a panel is to be lifted.

Load bearing – supporting the dead and live load of other members.
Load-bearing precast units – precast units which form an integral part of the building structure and which are essential to its stability.

**M**

Mark Number – the individual identifying mark assigned to each precast unit predetermining its position in the building.

Master Mold – a mold which allows a maximum number of casts per project; units cast in such molds need not to be identical, provided the changes in the units can be accomplished simply as pre-engineered mold modifications.

Matrix – the portion of the concrete mix containing only the cement and fine aggregates (sand).

Maximum size aggregate – aggregate whose largest particle size is present in sufficient quantity to affect the physical properties on concrete; generally designed by the sieve size on which the maximum amount permitted to be retained is 5 or 10 percent by weight.

Mitre – the edge of a panel that has been beveled to an angle other than 90 degrees.

Mockup – a section of a wall or other assembly built full size, or to scale, for purposes of testing performance, studying construction details, or judging appearance.

Module – a repeating or reoccurring dimension or detail.

Mold – the cavity or surface against which fresh concrete is cast to give it a desired shape; sometimes used interchangeably with form but made of fiberglass or concrete; a pattern or positive is built first and the mold is overlayed.

Mortar – a mixture of cement, sand, and water; when used in masonry construction, the mixture may contain masonry cement, or portland cement with lime or other admixtures which may produce greater degrees of plasticity and/or durability.

Mullion – a vertical precast unit appearing between windows and/or doors.

Muntin – horizontal precast appearing between windows and/or doors.

**N**

Nailer – a beveled wooden strip cast into a precast panel for the purpose of nailing flashing or roofing to it. The use of such material in concrete is not recommended.

Neoprene – a synthetic rubber bearing pad.

Normal weight concrete – concrete for which density is not a controlling attribute and usually having unit weights in the range of 135 to 160 lbs. per cubic foot.

Nosing – a projection such as that of the tread of a stair over the riser.

Overhang – the projecting area of a roof or upper story beyond the wall of the lower part.

Panel – an individual precast unit

Parapet – that part of the wall that extends able the roof line.

Patch – to repair a superficially damaged panel by filling the damaged area with concrete of matching color and texture.

Pier – a short column used as a foundation member in building construction.

Pilaster – column partially or completely embedded in a wall, or a portion of a wall enlarged to serve as a column.

Plate – a sheet of metal having a thickness of 1/8 inch or greater.

Plate washer – a special washer prefabricated from steel plate.

Poured in place – (see cast-in-place)
Precast concrete – a plain reinforced or prestressed concrete element cast in other than its final position in the structure; precast concrete can be architectural or structural.

Precast engineer – the structural engineer authorized by the manufacturer to ensure the adequacy of the structural aspects of the drawings, manufacture, and installation for which the manufacturer is responsible.

Preliminary - not completely finalized and reviewed.

Prestressed concrete - concrete in which there have been introduced internal stresses of such magnitude and distribution that the stresses resulting from loads are counteracted to a desired degree.

Prestressing bed - the platform and abutments needed to support the forms and maintain the tendons in a stressed condition during placing and curing of the concrete.

Pretensioning – a method of prestressing concrete whereby the tendons are elongated, anchored while the concrete in the member is cast, and released when the concrete is strong enough to receive the stresses from the tendon through bond.

Q
Quirk mitre – a corner formed by two chamfered panels.

R
Rebar – abbreviated term for reinforcing bar.

Reinforced concrete – concrete containing reinforcement, including prestressing steel, and designed on the assumption that the two materials act together in resisting forces.

Reinforcement – mesh, strand, or post-tensioning cables embedded in concrete and located in such a manner that the metal and the concrete act together in resisting loads.

Release – (1) the time at which the prestressed strands are severed prior to removing the prestressed units from the forms; (2) submittal of drawings; (3) stripping of precast panel

Release agent – (see form release agent)

Retarder – an admixture which delays the setting of cement paste and therefore of concrete

Retarder, surface – a material used to retard or prevent the hardening of the cement paste on a concrete surface within a time period and to a depth to facilitate removal of this paste after the concrete element is otherwise cured (a method of producing exposed aggregate finish).

Return – a projection of like cross-section which is 90 degrees to or splayed from main face or plane of view.

Reveal – (1) groove in a panel face generally used to create a desired architectural effect; (2) the projection of the coarse aggregate from the matrix after exposure.

Rib – (1) continuous vertical projection on a wall panel projecting a minimum of 6 inches from the panel face; (2) local thickening providing stiffness in concrete panels.

Rustication – a groove in a panel face for architectural appearance; also reveal.

Rustication strip – a strip of wood or other material attached to a form surface to produce a groove or rustication in the concrete.

S
Sand- that portion of an aggregate passing the No. 4 (4.76 mm) sieve and predominantly retained on the No. 200 (74 micron) sieve.

Sandblast – a system a abrading a surface such as concrete by a stream of sand, or other abrasive, ejected from a nozzle at high speed, by water and/or compressed air.
Sandwich wall panel – panel consisting of two layers (wythes) of concrete fully or partly separated by a layer of insulation; in employing this detail, metal shear connectors are usually required to tie the two layers of concrete together.

Sealants – a group of materials used to seal joints between precast concrete units and between such units and adjacent materials.

Sealers or protective coatings – materials used to coat precast concrete units for the purpose of improving resistance to water penetration or for improving weathering qualities.

Section – cut away view through a general plan or elevation view to explain details.

Segregation – the tendency for the coarse particles to separate from the finer particles in handling; in concrete, the coarse aggregate and drier material remains behind and the mortar and wetter material flows ahead; this also occurs in a vertical direction when wet concrete is overvibrated or dropped vertically into the forms, the mortar and wetter material rising to the top; in aggregate, the coarse particles roll to the outside edges of the stockpile.

Selfstressing forms – equipment which in addition to serving as forms for concrete also accommodates the pre-tensioned strands (or wires) and sustains the total prestressing force by suitable end bulkheads and sufficient cross-sectional strength.

Set-up – the process of preparing molds or forms for casting, including locating materials (reinforcement and hardware) prior to the actual placing of concrete.

Slab – precast or prestressed floor or roof members.

Spandrel – that part of a wall between the head of a window and the sill of the window above it. (An upturned spandrel continues above the roof or floor line.)

Spandrel beam – beam in a building frame which extends between exterior columns at a floor level.

Specifications – the type or printed directions issued by architects to establish general conditions. Standards and detailed instructions which are used with the contract drawings; contracted term, specs.

Stone anchor – an anchor commonly used to fasten cut stone units; such anchors are seldom suitable for use in precast concrete attachment.

Stress – intensity of force per unit area.

Stripping – the process of removing a precast concrete element from the form in which it was cast.

Strong back – a steel or wooden plate which is attached to a panel for the purpose of adding stiffness during handling, shipping, and/or erection.

Structural – a unit which carries live load or another unit’s weight.

Submitted – presented to the architect/engineer for review.

Systems building – essentially the orderly combination of “parts” into an “entity” such as sub-systems or the entire building; systems building makes full use of industrialized production, transportation, and assembly.

T

Temperature reinforcement – reinforcement distributed throughout the concrete to minimize cracks due to temperature changes and concrete shrinkage.

Tie – a closed loop of small size reinforcing bars that encircle longitudinal bars in columns and beams. (see stirrup)

Tolerance – specified permissible variation from stated requirements such as dimensions, strength, and air-entrainment.

Topping – concrete cast on erected
prestressed units to achieve a level floor or to aid the units in uniformly carrying loads.

V

Vibration - energetic agitation of concrete to assist in its consolidation, produced by mechanical oscillating devices at moderately high frequencies; external vibration employs a device attached to the forms and is particularly applicable to the manufacture of precast items; internal vibration employs an element which can be inserted into the concrete, and is more generally used for cast-in-place construction.

W

Wall panel – a component of a prefabricated wall which derives its strength and dimensional stability from a precast concrete element; the component includes any nonconcrete items incorporated in the element at the time of manufacture.

Warping – the bowing of a precast unit in two planes.

Weep hole – a hole provided for drainage through precast panel joints

Weld – to join metals by applying heat with a filler metal which has a high melting point.

Welded wire fabric – a reinforcing material composed of cold drawn steel wires fabricated into a sheet consisting of longitudinal and transverse wires arranged at right angles and welded together at all points of intersection.

Weld plate – a plate with attached anchors cast into concrete for the purpose of making a welded connection.

Workability – the ease with which a given set of materials can be mixed into concrete and subsequently handled, transported, placed, and finished with a minimum loss of homogeneity.