PCI
Precast/Prestressed
Concrete Institute

PARKING STRUCTURE SYSTEMS COMPARISON

Typical Long Bay (60') Construction

CRITERIA		TOTAL PRECAST CONCRETE: PRE-TOPPED (Double tee with 3.5", 4", or 5" thick pre-topped flange)	TOTAL PRECAST CONCRETE: FIELD-TOPPED (Double tee with 2.5"–4" CIP concrete topping slab)	CAST-IN-PLACE (CIP) CONCRETE POST-TENSIONED
Schedule 	4-story, 1000 stalls	6-7 months.	6-8 months.	10-12 months.
Cost 	Design costs	Same (precaster assisted).	Same (precaster assisted).	Same.
	Initial costs	$$	$$	$$$
	Life cycle costs	$	$	$
	Maintenance costs	$	$	$
	Financing costs	Potentially significant savings due to greatly reduced schedule.	Potentially significant savings due to greatly reduced schedule.	Typical.
	Time to revenue	Ties to construction schedule.	Ties to construction schedule.	Ties to construction schedule.
Site considerations 	Impact to neighborhood and/or campus	• Least site impact. • Approximately 95% off-site precast concrete, 5% site topping slabs/pour strips. • Fewest construction workers required on site. • Lay-down areas/stockpiling not typically required. • Minimal to no construction waste generated.	• Less site impact. • Approximately 80% off-site precast concrete, 20% site topping slabs. • Median number of construction workers required on site. • Lay-down areas/stockpiling not typically required. • Minimal to no construction waste generated.	• Greatest site impact. • All construction work on site. • Greatest number of on site construction crew required. • Lay-down area required (site stockpiling). • Significant site construction waste generated.
	Time to owner's use	Earliest beneficial occupancy possible.	Second earliest beneficial occupancy possible.	Longest time to beneficial occupancy.

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Constructability 	Market availability	Depends on proximity to PCI certified precast concrete producer plants. Production lead times vary depending on construction activity levels.	Depends on proximity to PCI certified precast concrete producer plants. Production lead times vary depending on construction activity levels.	Contractors readily available depending on proximity to an urban area, time of year, and construction activity. Forming materials could become scarce. Trained personnel could also become scarce based on activity levels.
	Overall quality, testing, finish, and schedule	• Precast concrete components produced at a PCI certified facility, under stringent audited guidelines and procedures. Minimized field topping (if required) is subject to varying conditions which could affect quality, depending on the extent that the contractor protects the concrete from the elements during placement and curing. • Factory quality control of beams, columns, girders, and flooring elements tend to produce a consistent, durable product. Least owner site monitoring required per the building code. • Quality of pour strips (which require less skilled labor and only minimal site forming) is dependent on general contractor, field conditions, and available labor pool. • Class A exterior finish integrated with system. (Options range from form finish gray concrete which could receive a painted finish, to color and sandblast, to integrated thin brick and stone.) • CIP concrete pour areas equal approximately 95% less volume of CIP concrete.	• Precast concrete components produced at a PCI certified facility, under stringent audited guidelines and procedures. Field topping is subject to varying conditions which could affect quality depending on the extent that the contractor protects the concrete from the elements during placement and curing. • Factory quality control of beams, columns, girders, and flooring elements tend to produce a consistent, durable product. Less owner site monitoring required per the building code. • Quality of topping slabs (which require less skilled labor and only minimal site forming) is dependent on general contractor, field conditions, and available labor pool. • Class A exterior finish integrated with system. (Options range from form finish gray concrete which could receive a painted finish, to color and sandblast, to integrated thin brick and stone.) • CIP concrete pour areas equal approximately 80% less volume of CIP concrete.	• All components are cast at the job site, subject to varying conditions which could affect quality depending on the extent that the contractor protects the concrete from the elements during placement and curing. • Quality is completely dependent on general contractor, field conditions, and available labor pool. • Owner must monitor all site concrete work for length of contract. Quality of concrete is dependent on general contractor, field conditions, and available labor pool. • Must provide alternative exterior cladding system (architectural, precast concrete, metal panels, etc.) to cover structure if aesthetics is a concern. • Introduction of closure strips requires curing of adjacent sections for 30 to 60 days before placement, which affects the overall schedule. • Delays related to post-tensioning.

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Quality 	Concrete strength	Typical precast concrete: 6000+ psi.	Typical precast concrete: 6000+ psi. Concrete used for topping: 4000 psi.	Typical: 4000–5000 psi.
	Typical w/cm ratio*	0.35–0.40 for precast concrete.	0.35–0.40 for precast concrete.	0.40–0.45.
	Confinement of strand	Bonded prestressed strands are more protected from corrosion, especially in concrete with lower w/cm ratios. Structural damage due to corrosion or severing of a prestressed strand is localized to an individual precast concrete member.	Bonded prestressed strands are more protected from corrosion, especially in concrete with lower w/cm ratios. Structural damage due to corrosion or severing of a prestressed strand is localized to an individual precast concrete member.	Unbonded post-tensioning creates potential for future corrosion when water gets into the sheathing. Loss of unbonded strands (either from corrosion or severing of the strands) can make large areas of the garage structurally deficient.
	Floor member strand location	Bonded prestressing strand in the lower half of the double-tee stems, beams, and lobby or roof slabs only.	Bonded prestressing strand in the lower half of the double-tee stems, beams, and lobby or roof slabs only.	Unbonded post-tensioning strands in slab areas to control temperature and shrinkage cracks, also in bottom of beams for load-carrying capacity.
	Joint sealant	At precast-to-precast joints and pour strip tooled joints.	At topping slab tooled joints aligned with precast-to-precast joints.	At construction joints.
	Expansion joint	300′–350′ spacing.	300′–350′ spacing.	300′ +/– spacing.
	Horizontal surface sealer	Not typically required, due to the high quality of concrete.	Required on CIP concrete surfaces by ACI-362.	Required on CIP concrete surfaces by ACI-362.
	Surface membrane	Same, when required.	Same.	Same.
Aesthetics (Exterior) 	Exterior finish	Precast concrete architectural finishes may be integrated into precast concrete elements at minimal cost.	Precast concrete architectural finishes may be integrated into precast concrete elements at minimal cost.	Typically secondary system is desired or required—often architectural precast concrete, EIFS coating, metal panel screening systems, or painted spandrels are used.
	Architectural finishes	Recommend integration in the exterior-facing precast concrete elements to maximize value to project.	Recommend integration in the exterior-facing precast concrete elements to maximize value to project.	Must be post-applied by separate trade, adding cost, time, and another on-site subcontractor that would impact site.
	Spandrel heights	Typically: 4′-0″ to 7′-0″.	Typically: 4′-0″ to 7′-0″.	Typically: 4′-0″ to 6′-0″.

* Lower water-cementitious material (w/cm) ratios greatly increase concrete's overall strength and durability, thus increasing service life and reducing maintenance of the concrete structure.

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Aesthetics (Interior) 	Interior appearance	26″ deep double-tee stems at 6′ on center.	26″ deep double-tee stems at 6′ on center.	30″ deep beams at 18′–36′ on center.
	Interior columns	Fewer columns, typically 36′–48′ on center.	Fewer columns, typically 36′–48′ on center.	More columns, typically 22′–36′ on center.
	Ceilings	Factory steel forms impart few if any seams at ceiling.	Factory steel forms impart few if any seams at ceiling.	• Floor forms impart wood grain or other regular seams at ceiling. • More susceptible to concrete paste leakage, irregularities, bug-holes, etc.
	Floor finish	Individual tees (10′–16′ wide) will have a plant-controlled, broom finish; full-depth joints with appropriate sealant.	Broom-finished in the field, with cut or tooled joints with appropriate sealant.	Same as field-topped.
	Floor uniformity	Regular control joints at 10′–16′ on center (based on tee width); very little shrinkage and temperature cracking.	Regular tooled control joints at 10′–16′ on center (based on tee width); shrinkage and temperature cracking typically contained at control joints and therefore not exposed to view.	Fewer floor joints; shrinkage and temperature cracks expected.
	Natural light	Fewer exterior columns; openings in litewall and interior shear walls allow interior to be open to natural light.	Fewer exterior columns; openings in litewall and interior shear walls allow interior to be open to natural light.	Slightly better natural lighting at exterior due to shorter spandrel height, but there are typically more columns. Interior lighting similar.
	Security	Most open interior available.	Most open interior available.	More obstructed views if there is a tight column spacing.
	Vibration	More perceptible.	More perceptible.	Less perceptible.
	Ventilation	Same.	Same.	Same.
	Lighting considerations	Same.	Same.	Same.
	Plumbing pipes	Same.	Same.	Same.
	Electrical conduit	Same.	Same.	Same.

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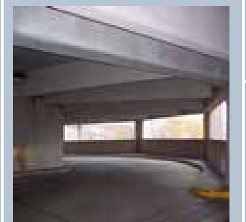
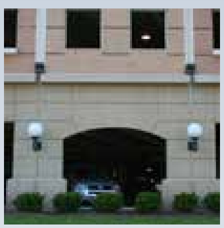
Design 	Obstructions inside	Requires fewer columns, thus increasing open space, visibility, and ease of navigation through drive lanes, as well as allowing for maximum flexiblity in parking space layout.	Requires fewer columns, thus increasing open space, visability, and ease of navigation through drive lanes, as well as allowing for maximum flexiblity in parking space layout.	Often has greater number of columns, increasing obstructions and reducing number of parking spaces, visibility, and ease of navigation through drive lanes.
	Floor-to-floor heights	Same or slightly more floor-to-floor height required. Typical double tee stem depth is 28″ + 3″ flange; end of bay/edge depth of structure beams is 36″.	Same or slightly more floor-to-floor height required. Typical double-tee stem depth is 26″ + 2″ flange + 3" topping; end of bay/edge depth of structure beams is 36″.	Same or slightly less floor-to-floor height required. Typical beam element depth: 36″.
	Fire rating	Same.	Same.	Same.
	Drainage systems	Same.	Same.	Same.
	Electrical systems	Same.	Same.	Same.
	Plumbing systems	Same.	Same.	Same.
	Elevator systems	Same.	Same.	Same.
	Wayfinding systems	Same.	Same.	Same.
	Ventilation systems	Same.	Same.	Same.
	ADA requirements	Same.	Same.	Same.
Maintenance 	Surface deterioration	Very rare bottom deterioration of load-carrying capacity reinforcing steel or prestressing strand. Very rare deterioration of top surface of pre-topped precast concrete tees. CIP concrete pour strips (if required) can have problems if poured with low quality concrete, if joints are not tooled properly, or if it is not protected from wind or temperature during curing.	Very rare bottom deterioration of load-carrying capacity reinforcing steel or prestressing strand. CIP concrete topping slab can have problems if poured with low-quality concrete, if joints are not tooled properly, or if it is not protected from wind or temperature during curing.	Most likely to get corrosion of load-carrying capacity reinforcing steel and post-tensioning strand due to potential poor concrete cover, leading to severe spalling over time. Top surface can have problems if poured with low-quality concrete, if joints are not tooled properly, or if it is not protected from wind or temperature during curing.
	Joints	Life expectancy of sealants is dependent on sealant material, preparation, installation, and exposure to climatic conditions, UV, plowing of snow, and de-icing chemicals. Covered levels require minimal maintenance; roof levels, which are exposed to environmental conditions, require periodic maintenance.	Life expectancy of sealants is dependent on sealant material, preparation, installation, and exposure to climatic conditions, UV, plowing of snow, and de-icing chemicals. Covered levels require minimal maintenance; roof levels, which are exposed to environmental conditions, require periodic maintenance.	Life expectancy of sealants is dependent on sealant material, preparation, installation, and exposure to climatic conditions, UV, plowing of snow, and de-icing chemicals. Covered levels require minimal maintenance; roof levels, which are exposed to environmental conditions, require periodic maintenance.

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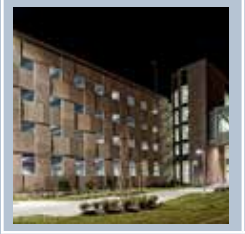
Lean construction 	Lean considerations	• Precast concrete lends itself to the application of lean construction principles. • Precast concrete elements may be tracked from production to installation. • Elements of the structure are factory-produced components. • Least overall waste, with least amount of work performed on site.	• Precast concrete lends itself to the application of lean construction principles. • Precast concrete elements may be tracked from production to installation. • Elements of the structure are factory-produced components. • Less overall waste, with less amount of work performed on site.	CIP concrete parking structures do not typically lend themselves to the application of lean construction principles. There is much waste and very little is factory-produced or componentized. Most work is performed on site.
Sustainability 	Sustainable sites—waste	Minimal to no construction waste.	Minimal construction waste.	Significant construction waste (from site-cast forming techniques).
	Sustainable sites—heat island effect	Can be used to support green roofs; uses finishes with high SRI values (>29).	Can be used to support green roofs; uses finishes with high SRI values (>29).	Can be used to support green roofs; uses finishes with high SRI values (>29).
	Sustainable sites—site impact	Low level of site impact; does NOT require on site storage. Precast concrete arrives right before being erected and is then erected with a crane and small crew. Requires the smallest possible site footprint.	Low level of site impact; does NOT require on site storage. Precast concrete arrives right before being erected and is then erected with a crane and small crew. Requires the second smallest possible site footprint.	High level of site impact; requires on site storage for forms, raw materials (e.g. rebar), shoring and bracing materials, etc. Also typically requires the greatest site footprint.
	Materials and resources—re-use	Can be re-used. Precast concrete components are individual and are able to be deconstructed and used elsewhere.	Can be re-used. Precast concrete components are individual and are able to be deconstructed and used elsewhere.	No re-use potential; CIP concrete creates a monolythic system that can only be taken apart by destroying the system.
	Materials and resources—recycled content	Precast concrete elements may include reinforcing as well as supplementary cementitious materials (SCMs such as fly ash, GGBFS, silica fume, etc.) which replace some of the cement content of the concrete—helping to lower the carbon footprint of the structure. SCMs are easier to use in precast concrete since primary curing happens at the manufacturer's plant before structural loads are placed on the components.	Precast concrete elements may include reinforcing as well as supplementary cementitious materials (SCMs such as fly ash, GGBFS, silica fume, etc.) which replace some of the cement content of the concrete—helping to lower the carbon footprint of the structure. SCMs are easier to use in precast concrete since primary curing happens at the manufacturer's plant before structural loads are placed on the components.	CIP concrete may include reinforcing steel and sometimes supplementary cementitious materials (SCMs such as fly ash, GGBFS, silica fume, etc.) which replace some of the cement content of the concrete, helping to reduce the carbon footprint of the structure. SCMs may be more difficult to use in CIP concrete since the primary curing takes place on the jobsite, where structural loads already exist and strength is needed quickly to continue the construction process.
	Materials and resources—regional availability	Certified Precast concrete producers are available within a 500 mile radius of projects in the US.	Certified precast concrete producers are available within a 500 mile radius of projects in the US.	Concrete can usually be delivered from a local source.

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