Garage Type Being Considered
Free standing, clear span, open parking structure

Desired Characteristics
Open parking structures are independent of other structures or buildings, but may service those facilities. Their systems and use are independent. Fire suppressant and mechanical systems are limited or are not required. They should allow for easy parking and maneuverability, two-way traffic flow, ease of re-striping as vehicle dimensions change, minimal maintenance/downtime, and practical geometry for parking the optimum number of vehicles.

These characteristics require designs with:
- Clear spans (50 to 60+ feet)
- Minimal columns
- Allowance for thermal movement and effective crack control
- Effective management, removal, and disposal of precipitation run-off, snow, and ice
- Footprints conducive to traffic flow and parking lay-out

Factors Influencing Design Criteria and Material Selection
- Construction and material costs
- Expected service life
- Ease of construction and limited use of specialized equipment
- Minimized labor force and the need for highly skilled and/or technical labor
- Timeframe to occupancy
- Ability to modify or make changes, such as an addition, to the structure in the future
- Maintenance requirements and associated costs
- Disruption and downtime associated with maintenance and repair needs
- Frequency between maintenance and repair cycles
- Location and land value
- Type(s) of facility being serviced by the parking structure (Educational, Government, Industrial, Military, Private, Commercial, etc.)

Preferred Systems in Use
1. Precast concrete columns, beams, and tees (topped and untopped)
2. Cast-in-place post-tensioned structures
    - Slabs and beams on cast-in-place columns
    - Pan Joist
    - Precast beams and columns with post-tensioned slab
3. Steel frame with formed slab
4. Others

Favored Systems for Washington, DC Metro Area

1. Precast systems topped and untopped
2. Cast-in-place post-tensioned systems

Dominant System In-Use (Our Opinion)

Cast-in-place post tensioned flat slabs and beams with cast-in-place columns. New construction costs range rough budget $30 to $38 per square foot.

Advantages

- Eliminates need for weld plates and exposed steel connections
- Allows for open spaces without shear walls, which can improve ventilation and security
- Expansion joints are generally required for long decks, otherwise, PT decks are joint free and crack free which provides added protection to embedded tendons and eliminates maintenance and replacement costs associated with sealant joints
- Modern day encapsulated tendons virtually eliminate the likelihood of tendon corrosion. Minimal use of mild reinforcing also reduces the likelihood of rebar deterioration and concrete spalls
- Cast-in-place construction eliminates the need to transport or lift heavy components into place
- Labor force required for cast-in-place is readily available
- Post-tensioned methods are generally accepted and provided by large general contractors
- Cast-in-place construction allows for flexibility in the field when considering construction irregularities, tolerances, and complex designs
- Lighting can be better and is easier to install than other systems because of the larger beam spacing and open spans
- Drainage slopes are easily incorporated during concrete placement

Disadvantages

- Higher skill level required to properly detail tendons and associated reinforcing
- Construction time is greater than precast systems
- Quality assurance is important to assure proper tendon placement and stressing operations
- Creep, shrinkage, and thermal movements must be properly designed for to prevent column damage (design columns for increased shear and moment) or spalls along rigid walls (provide pour strips)
- Tendon failures and blow-outs require skilled labor and design consultants to properly repair and analyze
- Cast-in-place construction requires substantial shoring until concrete systems have hardened and become capable of carrying loads. When constructing cast-in-place above existing structures, back-shoring is needed.

Most prevalent maintenance and repair items encountered, suggestions for preventive maintenance, and associated costs (rough budget)

- Cracks – rout and seal - $4.50/lineal foot
- Leaking expansion joint seals – remove and replace seal - $120/lineal foot
- Ponding – add drain and drain pipe – Roughly $1500/each
- Sealer – Install every 3 to 5 years after initial concrete cure - $.35/square foot
- Urethane membrane – Evaluate deck and consider installation after 10 to 15 years of service - $2.25/square foot
- End anchor deterioration – Lock-off strand and replace end anchor - $1,000/each – Provide encapsulated anchor with grease cap and appropriate non-shrink grout cover plug
- Broken strand repair– Replace broken section and re-stress - $850/each
- Deteriorated sealant joints – Replace every 5 to 7 years $6.00 per foot – Monitor twice per year (spring and fall) and replace as needed with global replacement every 5 to 7 years
- Spalls – Repair as needed $25 - $40 per square foot – Monitor slab twice per year (spring and fall) and repair as needed. Wash down garage by pressure wash or scrubber a minimum of twice per year (Once in the spring and once in the fall)
- Worn and faded line striping - Re-stripe every 3 to 5 years $.10 per square foot
- Procure the services of a qualified consultant to survey the parking garage and associated components every 3 to 5 years – cost varies; estimate $.15 per square foot.

ROUGH BUDGET EXAMPLE (RESULTS WILL VARY DRAMATICALLY FROM GARAGE TO GARAGE)

Assume 30,000 square feet PT flat slab and beams with conventionally reinforced columns, 2007 dollars, and no inflation. The table below is a very rough budget idea of costs associated with four individual maintenance scenarios and is based upon our historical data for conventionally reinforced and post-tensioned parking garages. The table below can vary dramatically depending upon the unique conditions encountered at each parking garage. The table considers rough budget costs only and does not take into consideration safety issues that arise in poorly maintained facilities and their potential impact on the public.

Years	Well Maintained	Average Maintenance	Poorly Maintained	No Maintenance
0-5	$15,000 (sealer)			
5-10	$20,000 (sealer and sealants)	$25,000 (Sealer, sealants, misc. repairs)		
10-15	$20,000 (sealer and sealants)			
15-20	$150,000 (Sealants, coating, Misc. repairs)	$375,000 (major repairs and coating)	$150,000 (needed repairs only)	
20-25	$10,000 (Misc. repairs)			
25-30	$40,000 (Misc. repairs and top coat)	$50,000 (Misc. repairs and top coat)	$650,000 (major repairs and coating)	$1,500,000 (Demo and Replace)
Total	$255,000	$450,000	$800,000	$1,500,000

By Steven Turner