



■ Commercial Buildings



### State-of-the-art Las Vegas Monorail™ will carry 19 million passengers in its first year

#### Driverless urban monorail rapid transit system along the east side of the Las Vegas strip, Las Vegas, NV, USA

The Las Vegas Monorail™ scheduled to begin operations in January 2004, is the nation's first fully automated, state-of-the-art, urban monorail rapid transit system. It will run along the east side of the famous Las Vegas strip and is expected to carry 19 million passengers in its first year of operation.

#### Reference Details:

**Client, General Contractor and Precaster** Granite Construction Company, Inc., Watsonville, CA, USA +++ **System Supplier** Bombardier Transit Systems, Montreal, Canada +++ **Structural Engineer** Carter & Burgess, Inc., Fort Worth, USA

**DSI Services** Supply of 80 tons 0.6" strand for pre-tensioning of precast elements; Supply and installation of 488 tons 0.6" strand for post-tensioning with 9, 12, 15 & 19-0.6" MA systems; Supply of approx. 35 tons 1-3/8" gr. 150 THREADBAR®; Technical assistance included stressing and grouting operations at the precast yard and on the job site.

The Las Vegas Monorail project is also the first public transportation system in the world that is totally funded by the private sector. Financing was generated through tax-exempt non-recourse revenue bonds. The bonds provided the capital needed to build the system and pay finance costs. The ongoing operations and maintenance will be covered by generated revenue. It is one of very few rapid transit projects in the world being implemented on a complete design/build/operate/maintain/finance system.

Linking seven stations over four miles to eight resorts and the Las Vegas Convention Center, the slick, driverless monorail will provide a quick and comfortable ride through the heart of the resort corridor. The monorail cars are the urbanized driverless version of the Mark VI monorail cars supplied for the Walt Disney World Resort, Florida. Offering many new attractive features, the fleet of nine 4-car trains represents the latest innovation in monorail technology.

The stations include two existing ones, MGM and Bally's that will be retrofit, new stations with two-levels (Las Vegas Hilton and Convention Center) or three-levels (Flamingo Hilton, Harrah's/Imperial Palace and Sahara Hotel).

The project includes also operations, maintenance and storage facilities.

Structural design utilized the latest ACAD technology that helped design engineers to accurately meet tolerances imposed by PCI and ACI codes. The new aerial guideway consists of 33 linked guideway structural frames and guideway switch structures: three crossover switches, one Y-Junction switch to accommodate the expansion of the system to Las Vegas Boulevard, and leading into the Maintenance and Storage Facility, one turnout switch and a four-position pivot switch. The typical guideway structural frame consists of five spans of dual, precast, post-tensioned guideway beams, made continuous through cast-in-place closure pours and continuity post-tensioning, with a minimum clearance of 5.5 m over public streets.

Spans for the guide beams, which both support and guide the monorail vehicles, average approximately 30 m, with the longest span being about 36.6 m. The slender 660 mm wide haunched beam section varies between 2.1 m deep at the column supports to 1.5 m at mid span. Guide beam spacing is typically 4.2 m on centers, increasing to 4.5 m when approaching crossover switches, and wider when entering center platform stations.

Guideway foundations typically consist of concrete cast-in-drilled-hole (CIDH) piles in the range of 1.2 to 1.8 m in diameter. At locations where the column size dictates a larger diameter cast-in-place-drilled hole, a caisson cap is provided. At those locations where the monorail alignment traverses through existing buildings, micro piles have been selected to minimize the disruption to existing hotel operations.

The typical cast-in-place column supports two guideway beams over the crossheads. The crossheads typically are tapered from 1.2 m at the tip to 1.8 m at face of column, and are 5.1 m wide. The typical column has a rectangular section, 1,422 mm x 812 mm. A series of reveals and colored sealer provide the columns with an attractive architectural look. The beam-column connection contains a structural steel support and steel hanger detail, which coupled with external supports, allows the beams to be positioned properly during construction. The assembly is such that guideway adjustment and super-elevation can be adjusted before pouring.





Unless subjected to nonstandard physical constraints, the guideway columns are centered between the two guide beams, with some adjustments required in areas where the beams are super-elevated. In locations with physical constraints, eccentric columns, single columns, and straddle bents are utilized. The typical cast-in-place column heights vary between the typical 7.6 m to 9.1 m columns to more than 18.2 m where the alignment spans over an existing pedestrian bridge at the Las Vegas Convention Center.

The steepest grades (6.5 %) occur at the Bally's Hotel and Casino, where the alignment traverses through the second floor of the existing Hotel. The next steepest slopes occur at the Convention Center, due to the presence of a large

elevated pedestrian walkway that links the Las Vegas Convention Center to a parking lot, west of Paradise Road.

Granite Construction built a state of the art precast plant facility where beams, girders and columns have been precast. They instituted a strict Quality Control Program that closely tracked the geometry and features of each individual beam. The design documents called for concrete beam strengths for up to 7,500 psi but field cylinder breaks had results between 9,000 to 12,000 psi at 28 days.

Granite installed the post-tensioning duct and anchorages and DSI did installation, stressing and grouting at the precast and job site locations. This geometrically complex structure with tighter than normal tolerances requirements was successfully accomplished by the design/build team. We would like to acknowledge the help of Mr. Carlos Banchik of Carter and Burgess, the main design leader engineer, for providing us with information and photographs.

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