ACCORDING TO DATA FROM THE SOUTHERN California Earthquake Center, California has a 99.7 percent chance of experiencing an earthquake of magnitude 6.7 or greater within the next 30 years. Of the many building types in use around the world, several types are among those more likely to collapse during such a significant seismic event, and of these, nonductile reinforced-concrete buildings are particularly vulnerable. By the most conservative estimate, as many as 50 of these structures in Los Angeles would be destroyed in a major earthquake. To address this concern, the City of Los Angeles recently proposed instituting what may be the most ambitious seismic safety regulations in California’s history, as these regulations would require building owners to retrofit thousands of buildings deemed to be vulnerable. Nonductile
An innovative but rigorous approach was required in adding the sixth floor because if the gravity loads and lateral force change limits given in chapter 34 ("Existing Structures") of the 2011 edition of the Los Angeles Building Code (LABC) had been exceeded, significant changes would have been required. Although the engineers demonstrated that the code did not require a full seismic retrofit, a seismic retrofit was nevertheless instituted because the owner wanted to be able to assure incoming tenants that the structure would be capable of resisting the force levels like new buildings in Los Angeles. All of the reinforced-concrete buildings built before 1980 required special attention.

Many of these buildings are of historical significance, including the Desmond building, in Los Angeles’s South Park commercial district. The Desmond began life in 1916 as an industrial building for the sale and service of Willys-Knight automobiles, produced by the Ohio-based Willys-Overland Motor Company, which owned the building until 1952. The building was subsequently occupied by various manufacturing companies until it was purchased by Desmond’s department store in 1941 and used as a warehouse and distribution center. Desmond’s merged with two other department stores that went out of business in 1986, and the building remained empty until it was purchased by Lincoln Property Company, of Dallas, in 2013.

The five-story building was designed by the Los Angeles architecture firm Morgan, Walls & Clements, although utilitarian in design, it reflected Beaux-Arts influences. The Willys-Knight showroom was located on the ground floor and featured 16 ft high ceilings. The second, third, and fourth floors were used for auto servicing, repairs, and customization, and the fifth floor housed autos awaiting delivery to customers.

In 2013 Lincoln Property contracted with the international firm Skidmore, Owings & Merrill LLP to renovate and seismically retrofit the building so that it could serve as office and retail space. The project would also add a sixth floor and a roof deck. Lincoln Property contracted with Suffolk Construction, headquartered in Boston, to perform the retrofits for the project. The work was completed in 2015, and the newly refurbished office space was purchased by the Los Angeles–based entertainment giant AEG, which moved more than 500 of its employees from around the city into floors 2 through 6. The Desmond warehouse has been transformed into high-quality office space with a ground-floor café, and the addition of a 7,000 sq ft rooftop pavilion brings its total floor space to 82,000 sq ft.
the structural modifications made since the building was constructed, using concrete of very low strength, were considered in the evaluations and retrofit design.

The five-story retail building was roughly 100 ft wide and 157 ft long, its concrete structure comprising columns linked by flat girders and conventional two-way reinforced floor slabs. The columns and beams constituted moment-resisting frames in two orthogonal directions, but they were considered to be nonductile because the detailing did not comply with code. There is a solid concrete wall along the entire north facade. Running along the property line, the wall was probably built directly against another building that no longer exists.

Although almost a century old, the building structure was found to be in very good condition. The building is on a list compiled by researchers at the University of California at Berkeley of structures seen as particularly vulnerable to damage in a strong earthquake. A nonductile building of reinforced concrete, the structure had been built using a low-strength (1,651 psi) concrete and low-yield-strength (40 ksi) reinforcement, the latter taking the form of twisted steel bars square in cross section. Knowing this, the design team worked with the Los Angeles Department of Building and Safety (LADBS) to develop an approach to satisfying the requirements of the code. As a result of comprehensive discussions with the department, the following was agreed:

• The 2011 LABC would be the governing code.
• The material properties assumed in the retrofit would be based on those shown on the original building drawings. No increase in the existing concrete and reinforcement material properties to account for respectively age and actual mill strengths would be assumed. This was due in part to variability in the results of tests in which concrete cores were taken from the original structure to determine if the concrete strength exceeded that in the original design drawings.
• Adding a sixth floor would be permitted only if the load and force change limits in the existing structural members, or “triggers,” set forth in chapter 34 of the 2011 LABC were not exceeded, even when the addition was considered. In determining whether the limits were exceeded, the building responses at the time of original construction were compared with those including all former and proposed structural modifications. Furthermore, these changes had to be considered cumulatively.

The building was on a list compiled by researchers at the University of California at Berkeley of structures seen as particularly vulnerable to damage in a strong earthquake. A nonductile building of reinforced concrete, the structure had been built using a low-strength (1,651 psi) concrete and low-yield-strength (40 ksi) reinforcement, the latter taking the form of twisted steel bars square in cross section. Knowing this, the design team worked with the Los Angeles Department of Building and Safety (LADBS) to develop an approach to satisfying the requirements of the code. As a result of comprehensive discussions with the department, the following was agreed:

• The 2011 LABC would be the governing code.
• The material properties assumed in the retrofit would be based on those shown on the original building drawings. No increase in the existing concrete and reinforcement material properties to account for respectively age and actual mill strengths would be assumed. This was due in part to variability in the results of tests in which concrete cores were taken from the original structure to determine if the concrete strength exceeded that in the original design drawings.
• Adding a sixth floor would be permitted only if the load and force change limits in the existing structural members, or “triggers,” set forth in chapter 34 of the 2011 LABC were not exceeded, even when the addition was considered. In determining whether the limits were exceeded, the building responses at the time of original construction were compared with those including all former and proposed structural modifications. Furthermore, these changes had to be considered cumulatively.

The building was on a list compiled by researchers at the University of California at Berkeley of structures seen as particularly vulnerable to damage in a strong earthquake. A nonductile building of reinforced concrete, the structure had been built using a low-strength (1,651 psi) concrete and low-yield-strength (40 ksi) reinforcement, the latter taking the form of twisted steel bars square in cross section. Knowing this, the design team worked with the Los Angeles Department of Building and Safety (LADBS) to develop an approach to satisfying the requirements of the code. As a result of comprehensive discussions with the department, the following was agreed:

• The 2011 LABC would be the governing code.
• The material properties assumed in the retrofit would be based on those shown on the original building drawings. No increase in the existing concrete and reinforcement material properties to account for respectively age and actual mill strengths would be assumed. This was due in part to variability in the results of tests in which concrete cores were taken from the original structure to determine if the concrete strength exceeded that in the original design drawings.
• Adding a sixth floor would be permitted only if the load and force change limits in the existing structural members, or “triggers,” set forth in chapter 34 of the 2011 LABC were not exceeded, even when the addition was considered. In determining whether the limits were exceeded, the building responses at the time of original construction were compared with those including all former and proposed structural modifications. Furthermore, these changes had to be considered cumulatively.

The building was on a list compiled by researchers at the University of California at Berkeley of structures seen as particularly vulnerable to damage in a strong earthquake. A nonductile building of reinforced concrete, the structure had been built using a low-strength (1,651 psi) concrete and low-yield-strength (40 ksi) reinforcement, the latter taking the form of twisted steel bars square in cross section. Knowing this, the design team worked with the Los Angeles Department of Building and Safety (LADBS) to develop an approach to satisfying the requirements of the code. As a result of comprehensive discussions with the department, the following was agreed:

• The 2011 LABC would be the governing code.
• The material properties assumed in the retrofit would be based on those shown on the original building drawings. No increase in the existing concrete and reinforcement material properties to account for respectively age and actual mill strengths would be assumed. This was due in part to variability in the results of tests in which concrete cores were taken from the original structure to determine if the concrete strength exceeded that in the original design drawings.
• Adding a sixth floor would be permitted only if the load and force change limits in the existing structural members, or “triggers,” set forth in chapter 34 of the 2011 LABC were not exceeded, even when the addition was considered. In determining whether the limits were exceeded, the building responses at the time of original construction were compared with those including all former and proposed structural modifications. Furthermore, these changes had to be considered cumulatively.
the respective systems resulting from an addition, and beyond these limits retrofitting is required. Not exceeding the triggers ensures that the existing load paths and load effects on existing members that are to be retained do not change significantly as a result of an addition.

To summarize the code requirements, if the gravity loads on a gravity system member increase by more than 5 percent as a result of an addition, that member must be retrofitted so that it can meet the requirements of the code for new structures. And if the demand-capacity ratio in a member supporting the lateral loads increases by more than 10 percent as a result of an addition when considering relevant load combinations, the member must be retrofitted to meet the code requirements for new structures. Similar requirements apply to the effects of alterations and are contained in respectively subsections 3404.3 and 3404.4 of chapter 34.

The 2011 LA BC requires that, in making these assessments, all changes to the structure as originally designed must be considered cumulatively in defining the addition or altered condition of the structure.

To meet these challenges, the design team devised a solution on the basis of the following principles:

- The new story to be added would be as light as possible, and gravity and seismic loads from this level would be well distributed over the building plan to minimize the load change to the original structure. This would be accomplished by using a steel structure; a metal deck roof diaphragm with no concrete fill, new columns aligned with columns in the existing building below to avoid gravity load concentrations; a distributed lateral system in the form of special moment-resisting frames with the columns pinned at their bases to avoid concentrating lateral load effects at particular locations; a lightweight interior raised floor; and lightweight exterior cladding. Moreover, there would be no heavy mechanical units or eccentric loads on the roof.

- The changes to the structure of the existing building would be minimal. The existing stair and elevator openings would be reused, and new openings for mechanical and toilet shafts would be minimized.

- The weights of finishes in the existing structure also would be minimized. The weights of architectural finishes were tightly controlled. Any heavy element that was no longer needed would be removed, for example, concrete ramps and raised, concrete-filled bays 6 in. thick that were once part of a car wash. Concrete stairs would be replaced by lighter steel stairs.

- Heavy mechanical and other service units would be located on the ground level.

- The existing exterior cladding system would be retained but would be repaired and refinished as needed.

- Any changes that had been made to the structure over the years that significantly affected the structural response would be undone.

On the basis of these principles, two analysis models were prepared, one for the original structure and the other for the structure with the addition and alterations that were planned. The loads and demand-capacity ratios in the two models were compared, and the results confirmed that the retrofit triggers would not be exceeded, obviating the need for a seismic retrofit.

There were two main reasons that the retrofit was not triggered. Because of its original use as an automobile retail facility, the structure was designed for a live load of 100 psf on all floors, including the roof. Because the plan was to reuse the building as office space, the live load would be only 50 psf; thus, a comfortable margin was available to accommodate the added gravity loads from the sixth-floor addition. Furthermore, by increasing the building’s height, it was possible, despite the addition’s mass, to minimally affect the seismic load on the modified structure. The base shear calculation for both the original design and the new design with the addition was governed by an empirical equation for the fundamental period that is a function of the height of the building. The table below summarizes the seismic loads calculated on the basis of the standard ASCE 7-05 (Minimum Design Loads for Buildings and Other Structures) on the original structure and the structure with the addition. (R in the table denotes the response modification coefficient.)

Meeting this goal, however, meant overcoming certain challenges. In 1971 a permitted modification was made to the building to fill an opening made for a ramp to the second-level slabs on the north side of the building. The infill structure was connected above the existing ramp and monolithically tied in to the surrounding structure. The infill structure not only added weight but seismic mass but also altered the lengths of columns and seismic load paths in the (Continued on Page 86)
Decking Out the Desmond

(Continued from Page 73) vicinity, making it virtually impossible not to exceed the code triggers. The team therefore decided to remove the infill structure and revert to the original condition in the area. This move, along with the removal of existing concrete finish toppings on two floors, ensured that the triggers would not be exceeded.

To capture the rentable space at the second floor above the ramp, a new, independent floor slab structure was added. Framed in steel and having a metal deck, this independent composite structure features footings and a special moment-resisting, steel frame lateral system of its own. It was seismically isolated from the base building structure with an 8 in. seismic joint along the perimeter.

Even though the code triggers had not been exceeded, the owner decided to provide a seismic retrofit system for the building to ensure code-level seismic performance in a major earthquake while at the same time preserving as much of the original character as possible. Ductile concrete shear wall piers were placed at each perimeter column on the west, east, and south sides and were aligned with the solid portions of the exterior facade cladding so as not to encroach upon the windows (see the figure at the top of page 71). The shear wall piers were linked to one another with upturned ductile link beams at each level to create a ductile linked shear wall system. On the north side, the location of the solid concrete wall, two shear walls, each one bay long, linked by collectors were provided (see the figures at the top of page 69 and the bottom of page 71).

The LADBS mandated that the seismic retrofit system would have to be treated as an alteration to the original structure and considered cumulatively with the addition and other alterations made since the original design. It further stipulated that the percentage changes to loads and demand-capacity ratios in the retained gravity and lateral system components in relation to those in the original structure could not exceed the 2011 LABC triggers. The gravity load triggers were not an issue, as discussed above, but it was necessary to carefully tune the stiffness of the lateral-load-resisting elements to ensure that the load paths were not altered to an extent that the demand-capacity ratios would increase by more than 10 percent. The LADBS also required that, for the internal columns, which would now serve as gravity columns, the deformation compatibility requirements given in subsection 12.12.4 of ASCE 7-05 would have to be met.

Once again, an analysis model of the retrofitted original structure was built, including the sixth-story addition, and the percentage changes in the loads and demand-capacity ratios in the retained gravity and lateral system members of the original structure were rigorously checked at a member-by-member level. The results were found not to exceed the triggers. Such new members as special moment-resisting frames and shear walls were designed in accordance with the requirements of the 2011 LABC for new structures. Composite fiber wrap confinement was provided at the top and bottom ends of the interior gravity columns to ensure the required deformation compatibility.

New, interconnected foundations meeting the requirements of the 2011 LABC for new structures were provided under the new vertical column piers and shear walls to support their weight and seismic load effects. The end zones of the added shear walls on the north facade were found to experience tension because of the amount of seismic load they attracted. A typical solution to that problem would have been to add a deep foundation system, for example, micro-piles, but that was not feasible in this case for a number of reasons, among them the location of the wall along the north property line. Instead, the engineers designed a 10 ft high reinforced-concrete gravity ballast wall along the entire north facade that linked the two existing shear walls below grade and used the full depth of the foundation wall above its strip footing (see the figure on page 72).

With this retrofit, the performance of the structure improved dramatically. The drift at the second story fell from 6 percent to 1.4 percent in the north–south (transverse) direction and to 0.8 percent in the east–west (longitudinal) direction.

The Desmond building is one of the first of many potential renovations of historically significant properties in the South Park district. Nowhere else in the city are so many older buildings of this type to be found, and creative companies are eager to take advantage of the possibilities they offer.