SEISMIC RESPONSE, EVALUATION, AND RECONSTRUCTION OF THE DVA SEPULVEDA CAMPUS FOLLOWING THE 1994 NORTHRIDGE, CALIFORNIA, EARTHQUAKE

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SUMMARY

The Department of Veterans Affairs Sepulveda Medical Center is located approximately four miles from the epicenter of the M6.7 January 17, 1994 Northridge Earthquake. This campus of buildings, constructed in the 1950s, suffered varying degrees of damage to over 40 buildings including severe damage to the main hospital. After the earthquake, the medical center went through a systematic process that included immediate post-earthquake response, post-earthquake inspections and evaluations, master planning for the facility's new mission, design and construction of new buildings and rehabilitation of existing buildings. This work to rebuild after Northridge represents an important case study in post-earthquake response, evaluation and reconstruction of a major facility.

INTRODUCTION

At 4:31 A.M. (PST), on January 17, 1994, a magnitude 6.7 earthquake struck Southern California near the City of Northridge approximately 20 miles north-west of downtown Los Angeles. The focus of the earthquake was located on the eastern edge of the Oakridge Fault at a depth of approximately nine miles. The earthquake and its aftershocks caused over 60 deaths and widespread damage in the San Fernando Valley and surrounding areas of Southern California with damage estimates exceeding $30 billion (US).

The Department of Veterans Affairs (DVA) Sepulveda Medical Center, located less than four miles from the epicenter of the earthquake, was seriously impacted by the large temblor. The peak horizontal ground acceleration measured at the site was 0.94g. The campus of over 50 buildings, the majority of which were constructed as low-rise concrete and masonry shear wall buildings in the 1950s, suffered extensive structural and non-structural damage that resulted in complete evacuation of the medical center. The story of the medical center in the aftermath of Northridge represents an important case study in post-earthquake response, evaluation, and reconstruction of a major medical facility.

POST-EARTHQUAKE RESPONSE

On the evening of January 17, 1999, Degenkolb dispatched a number of engineers to the Sepulveda Medical Center to survey the damage and help the staff at the medical center decide what buildings were safe to occupy and which ones needed to be closed.

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LESSONS FROM RECENT EARTHQUAKES: Field observations: Northridge earthquake (1994), Campus planning, Damage survey, Hospital, Medical Center, Northridge earthquake, Post-earthquake inspection, Seismic retrofit, Sepulveda, V A

When the team arrived, almost all of the buildings on the campus had been evacuated. Patients from Building 3, the main hospital building, were still in their beds on the front lawn of the hospital awaiting transportation to other facilities. In Building 2, as well as in other buildings, sprinkler pipes had broken and water was running out of the front door. We learned that station personnel would not enter the building to shut off the running water until we surveyed the building and deemed it safe to enter. Very few of the buildings had electric power.

The survey of each building started with a review of the structural drawings available at the site, an inspection of the building perimeter, and a limited investigation of the building interior. Because of the damage already sustained by the buildings, some limited interior finishes were removed during the survey to expose structural elements. Because of the lack of power, flashlights were needed to make our way around the building's interior. Waterproof boots were necessary in some buildings because of the inches of standing water on the floors.

It was important that the buildings be surveyed quickly, both because of the large number of buildings to survey as well as the desire of the station personnel to get back into the buildings to retrieve supplies. We quickly determined that a more extensive investigation of each building would be required after the initial survey to document damage and develop repair recommendations.

In four days, 50 major buildings at the campus were surveyed and tagged with a green, yellow, or red tag using the ATC-20 methodology to indicate if the building was safe to occupy, safe only for limited entry, or unsafe to occupy. When the survey was complete, 39 buildings had been green tagged, 11 buildings yellow tagged and no buildings red tagged.

The buildings were yellow-tagged for a variety of reasons. Two were trailers that had fallen off their supports. Four were wood-framed residential structures that had lost their chimneys. Three had extensive cracking and damage to contents (see Figure 1). The last two, however, had more significant damage.

Building 3, the largest building at the medical center and the main hospital, suffered the most extensive and significant structural damage. It was a 6-story reinforced concrete shear wall structure with several wings separated by joints. Extensive cracking of the concrete shear walls and floor diaphragms, pounding damage between adjacent wings, and spalling of coupling beams over corridors were noted (see Figure 2). Most significantly, one of the building wings had rotated at the base away from the main building causing a permanent offset of over 8 inches at the roof.

The other significant building damaged, Building 40, was the main boiler plant for the entire campus. It was a tall one-story reinforced brick structure with large window and roll-up door openings on both sides. Significant damage occurred to the exterior reinforced brick walls that resulted in movement of the interior concrete frames. The movement was large enough to cause extensive cracking at the base and top of the concrete columns supporting the concrete roof.

Except for the poor performance of a few buildings, most of the buildings at the Sepulveda Medical Center performed very well. Some of the important lessons of the post-earthquake response were:

- Campus administrators should know who to call immediately following an earthquake and should take steps to ensure that engineers are available and can respond quickly to assess damaged buildings.

- If engineers are not on site or are not immediately available, specific training of station personnel with ATC-20, *Procedures for Post-earthquake Safety Evaluation of Buildings* could have prevented the evacuation and closing of a number of campus buildings that were later found to be safe to occupy.

- Water and gas valves should be located on the building exterior or in readily accessible locations so that they can be safely turned off immediately after an earthquake if necessary.

- A single broken sprinkler head or a single unbraced pipe that breaks at a fitting can cause extensive non-structural damage in a building with a wet-pipe fire-protection system.

- Of all the buildings that could be heavily damaged in a major earthquake, the main hospital and boiler plant (as well as the emergency generator) are the ones most likely to cripple a major medical center.

Figure 1: Left photo shows typical earthquake damage to contents in laboratory space.

Figure 2: Right photo shows spalling of brick veneer due to pounding between wings at Building 3.

POST-EARTHQUAKE INSPECTION AND EVALUATION PROGRAM

Three months following the earthquake, the DVA initiated a campus-wide study to assess the damage to the Sepulveda Medical Center in detail. The purpose of the effort was twofold: First, to document the damage and second, to make recommendations of how to best accomplish the facility's revised mission within the constraints of a limited reconstruction budget. The team was led by LBL+SMP Associated Architects and included a full team of consultants including structural, mechanical, electrical and civil engineers, security, communications, accessibility, signage, and cost consultants.

The first step was to establish priorities about what buildings to study. Ten buildings were identified as initial priorities and eight as secondary priorities. In addition, campus-wide studies were made of site utilities, disabled access, irrigation, tunnels, signage, and communication and security systems. Due to our earlier findings, it was decided early in the process to demolish and replace Building 3 (the main hospital) and Building 40 (the boiler plant).

The report was presented as a collection of separate sections on each building and system. In order to provide a consistent framework for each report, each consultant was asked to divide their work into three major sections: Initial Assessment, Expanded Assessment, and Mitigation Measures. The Initial Assessment was a general overview of the damage, but not necessarily of any specific unit or floor. The Expanded Assessment included a focused and detailed floor-by-floor, unit-by-unit assessment of damage qualified as Minor, Moderate, or Major.

The final category, Mitigation Measures, was divided into three subcategories, Short Term, Intermediate and Long Term, in order to recommend correction measures appropriate to each time frame. Short Term recommendations included those that could be undertaken right away to return buildings to their pre-earthquake condition as well as addressing important safety concerns. Intermediate recommendations included the seismic upgrade of structural deficiencies as well as minor mechanical and electrical upgrades and the correction of

fire/life safety and handicapped accessibility issues. Long Term recommendations were intended to take into account the master planning needs of the future facility.

The report included a comprehensive photographic survey of the most visually descriptive and typical damaged locations, including the building name and number, location of the damage, description of the damage, and a key plan locating the viewpoint at which each photograph was taken.

The large amount of detail included in the report was necessary to develop an accurate cost estimate as well as to make sure that the damage was assessed completely by each member of the team. Some of the important lessons of the post-earthquake inspection were:

- A comprehensive survey should be undertaken soon after a major seismic event to expedite the gathering of information critical to making decisions.
- Survey teams should be multidiscipline in order to cover all the possible aspects of earthquake damage as well as collateral damage (contents, etc.) and damage to systems.
- A consistent structure for each building report makes comparisons and alternative scenarios easier to develop.
- Because of the level of detail of the information collected and documented by the survey team in terms of maps and photographs, more accurate repair cost estimates could be made.
- A detailed report is important as a permanent record of what damage occurred so that years later, long after everyone that produced the report is gone, the report can still be used.

CONCLUSIONS OF THE DAMAGE ASSESSMENT REPORT

After the earthquake, the design team led the medical center through many different options and scenarios for the future of the medical center. There were many factors that influenced the final outcomes:

- Building 3, the main hospital on the campus, was damaged beyond economical repair and would require a large amount of money to replace in-kind.
- Many of the major buildings on campus needed to have expensive repairs due to earthquake damage and also needed major seismic upgrades to meet life-safety requirements.
- All of the buildings on the campus were about 45 years old and many needed major upgrades to mechanical and electrical systems to meet modern healthcare needs. Many had asbestos problems that had been uncovered but not yet addressed as well as required work on deferred maintenance items and accessibility upgrades.
- The DVA had other facilities within 25 miles of Sepulveda that overlapped some of the functions of the medical center.
- The role of the DVA in the community was changing as the population of veterans requiring medical care was dwindling.
- More of the health care emphasis was on out-patient care rather than in-patient care.

After working many months with the DVA in Washington and the local medical center staff, it was decided to replace Building 3 not with a new hospital building but with a new out-patient clinic. Because it would have no surgery, all in-patient surgery patients would be served by a nearby medical center in West Los Angeles. In all, they decided to add a total of three new buildings to the medical center: A new 240,000 square foot out-patient clinic, a new 12,200 square foot central communication building, and a new 5,200 square foot boiler plant.

The complete team recommendations were made in five major categories in order to completely address all the work required for the future (see Figure 3):

- Buildings to be demolished and replaced
- Buildings to be upgraded in the short term (within 5 years)
- Buildings to be upgraded in the intermediate term (within 10 years)
- Buildings to become unoccupied and eventually demolished
- Buildings to remain as-is

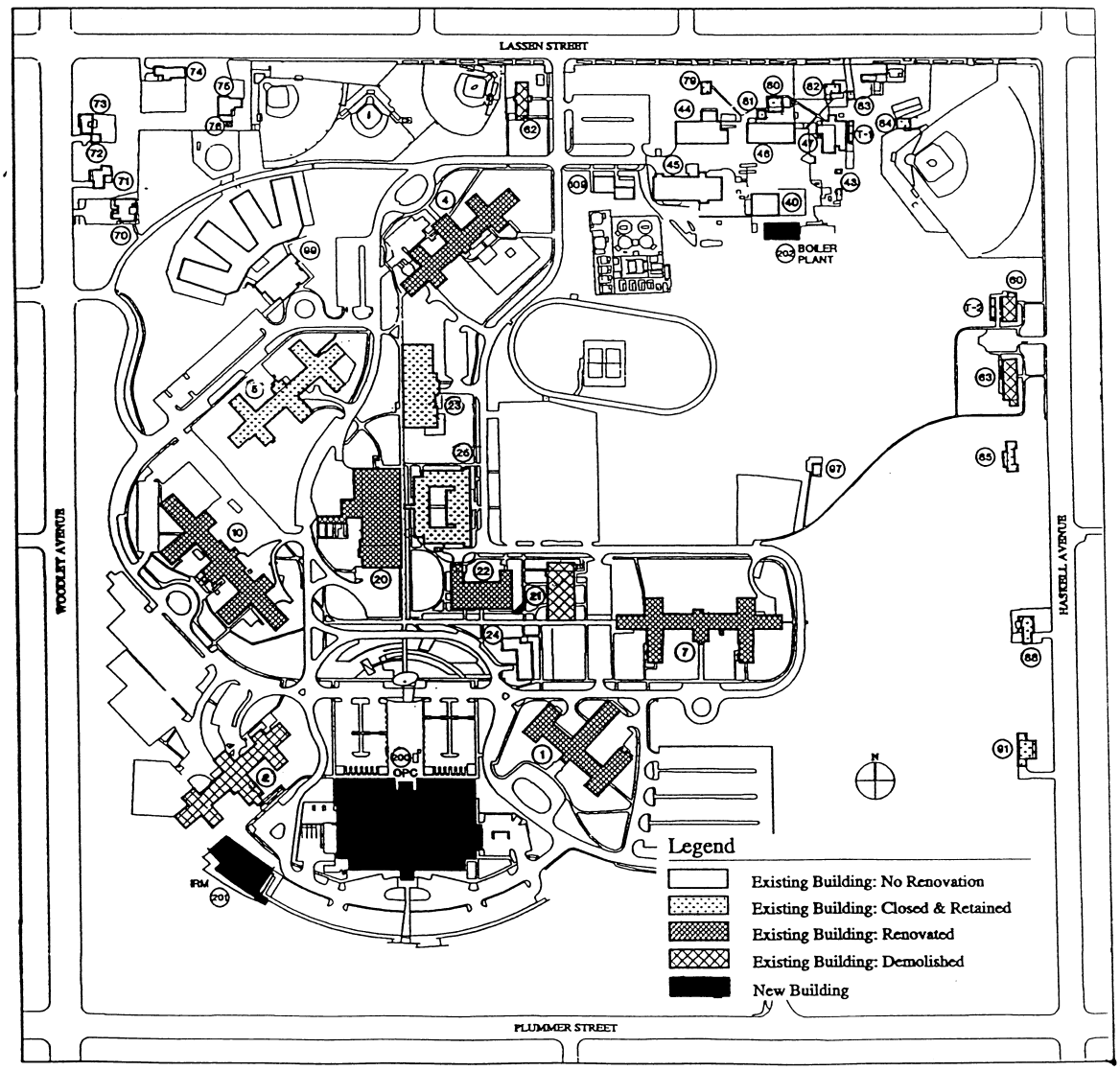

Figure 3: Map of VA Sepulveda Campus with results of Damage Assessment Report.

In addition, cost estimates were developed for the entire program. The budget of the new buildings was roughly $56 million, the majority for the new out-patient clinic. The budget to demolish buildings was approximately $2 million. The budget for both minor and major remodel work including all seismic repairs and upgrades on the remaining major buildings was approximately $25 million.

DESIGN AND CONSTRUCTION OF NEW REPLACEMENT BUILDINGS

The first priority of the reconstruction plan was to design and construct the new out-patient clinic. Even though repairs started immediately to many existing campus buildings, much of the energy of the staff focused on the new building. It was important to the medical center to have a very visible construction process in order to help promote the concept that the center was rebuilding and re-energized.

To create a new focus for the medical center, the team placed the building at a prominent location at the very front of the campus. After the new clinic was operational, Building 3 was demolished and a parking lot constructed in its place.

Because the old hospital had been so badly damaged, the medical center wanted to ensure that the new clinic would be able to withstand the next earthquake with minimal damage and continue in operation. The structural design team was able to utilize the actual accelerations from the Northridge earthquake recorded at the Sepulveda site to set the criteria for the new buildings. This, along with the use of the DVA's own seismic criteria, H-18-8, will help ensure the continued operation of the facility after another major earthquake. The team developed an efficient column grid for the building and utilized a dual lateral force resisting system of eccentrically braced steel frames and a complete back-up moment frame. Because of the close proximity of a trace of the Oakridge fault, the foundation system consisted of a 4-foot thick mat over the entire building footprint.

To expedite the construction process, the team created a complete set of documents up to a design development level. A design-build project delivery approach was then undertaken to complete the design and construct the new facility. This process had its advantages and disadvantages. The advantages were a quicker schedule, fixed price, and fewer conflicts between the designers and the contractors since they were on the same team. The main disadvantage was that the VA and the medical center lost a great deal of their ability to make changes as the process progressed.

The two other new buildings, the new communications center and the new boiler plant were smaller than the out-patient clinic, but just as crucial to the future operation of the medical center. As luck would have it, all the campus' telecommunications and central computer equipment was located in the basement of the heavily damaged Building 3. A new building was needed nearby to house all of the equipment as well as be able to keep the center operational in the event of another major earthquake. A one-story, partially underground building was constructed just west of the new out-patient clinic. It included room for all the wiring and computer equipment for the entire campus as well as its own emergency generator and fuel supply.

The new boiler plant was located just south of the old boiler plant to minimize the amount of re-piping that was required. This building also was designed to remain operational in the next earthquake. It included a complete steel frame gravity system and concrete shear walls on the entire building perimeter. New boilers were set by crane into the building before the roof was complete.

All three new buildings were in operation about 4 years after the date of the Northridge earthquake. Some of the important lessons learned during the design and construction of the new facilities were:

- New buildings are beneficial to start as soon as possible. The staff of the center eagerly watched the new construction and saw it as evidence of the rebuilding and rebirth of the campus.

- After the start of the design-build process, it was important to retain the original design team to answer questions about the documents, provide peer review during the remaining design and construction, and continue to act as consultants for the owner.

- Owners should consider designing replacement buildings to a higher performance objective than life-safety, especially if the earthquake hazard is well known at the site.

REPAIRS AND SEISMIC STRENGTHENING OF KEY BUILDINGS

As the new buildings were being completed, the medical center turned its attention to the existing buildings that needed repair and strengthening. Because of significant damage, some buildings or areas within buildings had to be closed until they could be repaired. Other buildings that were less damaged were opened immediately and closed before scheduled for repair.

The original master plan called for six major buildings on the campus to be repaired and renovated. All six were damaged to varying degrees during the earthquake and drawings were prepared for each detailing the areas of each building needing repair. Typical repair work included epoxy-injecting cracks in reinforced concrete walls and slabs. In addition, each building underwent a detailed seismic study to determine if it met the DVA criteria for existing buildings. For those buildings not meeting the criteria, detailed strengthening drawings were prepared.

Because patients and medical personnel occupy them, the DVA required two of the buildings, 4 and 10, to remain in operation after an earthquake. These two buildings were evaluated as essential facilities using the DVA's H-18-8 standard. They both needed extensive strengthening including new and strengthened concrete shear walls, reinforced diaphragms, new collectors and strengthened connections. Building 10 is currently under construction and is planned for completion in the summer of 2000. The strengthening of building 4 was designed but never constructed due to lack of funds.

The other four buildings were designated ancillary facilities by the DVA and evaluated to a life-safety standard using FEMA-178. Buildings 7 and 20 were studied and found to comply with the life-safety standard. Both have been recently repaired and are currently in use. Buildings 1 and 22 were found to need strengthening to meet the life-safety standard. Both buildings needed a few new concrete shear walls and some new collectors at the roof and floors. Neither building has yet been repaired or upgraded due to lack of funds.

FUTURE PLANS FOR THE MEDICAL CENTER

Five years after the Northridge earthquake, the medical center has accomplished a great deal. A new state-of-the-art out-patient clinic serves as the cornerstone of the rebuilt campus. Building 3 has been demolished and replaced by a new central parking area for patients. Both a new boiler plant and central communications building have been constructed to restore and protect essential services to the entire campus. Several buildings have been repaired and others, including one essential structure have been strengthened.

Yet there still is a great deal of work to do. Several buildings still require seismic repairs and upgrades. Other buildings identified in the master plan need to be demolished. The center continues to struggle with construction disruption caused by repairing damage due to the earthquake. With the changing face of health care, especially within the DVA, it makes the challenges even greater as the Sepulveda medical center moves into the next century.

REFERENCES

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