UPDATING CORPORATE SEISMIC PROGRAMS IN RESPONSE TO RECENT CALIFORNIA EARTHQUAKES

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SUMMARY

A major California healthcare system has developed, and maintains, a seismic program for well over fifteen years. The program addresses issues such as preparedness, post-earthquake response, seismic evaluation and upgrade of existing facilities, and requirements for new construction. One of the unique features of the program has been how it has been modified and augmented as a result of lessons learned in California earthquakes such as the 1989 Loma Prieta and 1994 Northridge events.

OUTCOMES

A major California healthcare provider has been pursuing seismic hazard mitigation since the 1971 San Fernando earthquake. This group owns facilities throughout California and has been providing healthcare for well over fifty years. They have been proceeding in earnest since the mid 80s and developed formal hazard mitigation program after the 1989 Loma Prieta earthquake. Their program was instigated by the damage that some of their facilities experienced as a result of the 1971 earthquake. Their program goal, which has essentially remained the same since 1971, has been to rehabilitate all of their facilities to meet a minimum seismic life-safety level as soon as practical and when possible to upgrade the patient care facilities to a functionality level.

The seismic program began with the evaluation of selected facilities that were similar to those that were damaged in the 1971 earthquake. These studies were done from a structural engineering perspective and focused on bringing the buildings into compliance with the hospital code. That process uncovered a significant amount of work that needed to be done, and raised a practical concern about doing extensive seismic strengthening without considering the other functional deficiencies in the facilities. The program grew to consider each facility in its entirety with consideration given to all seismic and operational deficiencies.

Between the 1971 and 1989 earthquakes the program was conducted in a "behind the scenes" environment. During that time all of the facilities were evaluated both for life-safety and functionality, and upgrade schemes were developed and priced. All information was kept confidential to protect the operations. Because of the extent of damage experienced in the 1989 Loma Prieta earthquake the seismic program became more visible and formalized. The basic evaluation and upgrade program continued to identify facility strengthening needs while at the same time other associated programs were developed. These included setting rigorous standards for new buildings, and a program for doing pre-purchase or pre-lease seismic evaluations of all properties that were being acquired. In addition, and in a parallel effort, a sophisticated emergency response program was established that allows the group to respond effectively after a damaging earthquake. Information from the seismic evaluation and upgrade program was used to tailor the response plans to the inventory of buildings.

As with any long term program there is a need to provide continuous monitoring to assure that the goals of the program remain pertinent and credible. Such a monitoring program has been in place since the beginning and has allowed this group to update their seismic program to include the lessons learned from the Northridge and Kobe earthquakes.

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Seismic Evaluation and Upgrade

The seismic evaluation and upgrade program began with the development of a complete inventory of all buildings in the system. These buildings were screened from a seismic perspective using the ACT-14 criteria. The screening identified which buildings met the life-safety criteria and which buildings needed to undergo a detailed evaluation to determine their performance capabilities. Patient care facilities that met the minimum standard where evaluated for functionality based on the then current hospital code. All buildings were given a performance rating based on this initial screening.

The program was overseen by a seismic hazard reduction committee made up of both consultants and members of the facilities group within the company. A detailed inventory of all buildings was maintained that included their status and need for future evaluation and upgrade. Within a few years the inventory was essentially complete and included a seismic rating for each building that identified it as either a life-safety concern, a functional concern, a code compliant building, or a building deleted from the inventory. This process provided a rich inventory of information regarding the seismic condition of the facilities that became very useful from a planning standpoint.

There were a number of key assumptions made that streamlined the inventory and evaluation work and focused the upgrade program on when rehabilitation work could occur during the least disruptive and least costly times. It recognized that facilities were best strengthened during the normal remodel cycle that is dictated by the rapid changes in healthcare delivery. Most recently the inventory has served as an effective means for this system to comply with the requirements of SB 1953. Those requirements were adopted in California in 1998 and require all hospital and hospital systems to update their facilities to comply with the current functionality codes by 2030.

One of the many lessons learned during the evaluation and inventory process was the need to evaluate all facilities being purchased or leased to assure that they met the corporate seismic standards and thus did not increase the inventory of buildings that needed seismic correction. Since California's building codes for healthcare facilities requires similar performance standards, all new facilities were deemed to comply.

Pre-Purchase or Pre-Lease Seismic Evaluations

It is not uncommon for due diligence studies to be commissioned before properties are purchased or leased. It is uncommon for consideration to be given to seismic performance objectives. This California healthcare provider elected to apply their seismic performance standards to the properties that they were purchasing and those that they were leasing. This was particularly important since their leases on the average were renewed every four to seven years.

Pre-purchase -- due diligence studies are normally done by professionals who specialize in building construction and who are experts in the requirements of the modern code. Since most property being purchased do not meet the latest seismic provisions, the expertise normally available for these studies often needs to be supplemented with professionals knowledgeable in the available performance-based evaluation methods that are available. This California healthcare provider requires all properties to be evaluated for a seismic performance based on the latest evaluation techniques. Originally ATC-14 was used; this was supplemented by FEMA 178, and most recently by FEMA 310.

The initial due diligence report includes a tier one evaluation with recommendations for tier two, detailed evaluation if necessary. It is not uncommon for properties to be acquired that do not meet the current seismic standards, though the needed seismic rehabilitation is added to the development plan for the facility.

The pre-lease investigation is generally a seismic/structural investigation only and aimed at the life-safety performance objective. Modern evaluation tools such as FEMA 310 are used to carry out the evaluations. Since a lease is only for short period of time and since there is generally a wide variety of properties available only the tier one evaluation tool is used for the investigation. A training program has also been undertaken to teach the real estate division how to identify properties for lease that will meet the minimum standards without evaluation. Currently, the pre-lease of seismic evaluation is a validation of the real estate division's selection.

Pre-Earthquake Preparedness Plan

Any large business that has experienced a disaster knows the value of pre-disaster planning. This is especially true for earthquakes, where detailed response procedures, orchestrated out of an emergency operations center, are carefully planned. Often, professional, emergency response planners develop response plans. Ironically while these groups have very advanced techniques for responding to the disasters, they often do not take into account the information known about the expected seismic performance characteristics of the facilities.

Emergency response after a moderate or large earthquake generally follows three phases. The first phase is the immediate response, when emergency actions, including damage assessment, need to be taken following a prescribed plan. Swift action is needed to evacuate personnel from hazardous conditions, and retrieval of important inventories and records. The second phase involves the detailed assessment of all facilities to determine their long term safety and usability. The third phase covers the needed repairs and at times reconstruction. The first phase can last up to thirty-six hours, the second up to seven days, and the last phase can extend for many years depending on the extent of damage.

Based on their experiences in the 1989 Loma Prieta earthquake this California healthcare provider realized that there was a wealth of information contained in the seismic evaluation reports that would be useful to their staffs immediately after a damaging earthquake. For each medical center campus, the seismic inventory included the expected performance characteristics for each building. This information, along with the expected deficiencies for the buildings that did not meet the minimum standards, turned out to be quit useful in preparing for the next event.

As would be expected, the first decisions related to evacuation must be made by the facilities personnel that are onsite at the time of the earthquake. In the case of this California healthcare provider, the decision is made by the medical center administrator on the advice of the chief physician and the facilities engineer. In the 1989 Loma Prieta earthquake, there were many examples of administrators exercising good intuition and making proper evacuation decisions. There were also some examples of miss interpretation of the importance of particular styles of damage, and facilities were evacuated unnecessarily. This particularly dangerous at a medical center where the rapid evacuation of critically ill patients can be fatal.

The building inspection portion of the emergency preparedness program was augmented with a set of post-earthquake inspection notebooks that contained procedures, lists of deficiencies, and drawings for all the buildings at each medical center. The information in the notebooks was based on the experience in the 1989 Loma Prieta earthquake with post-earthquake inspection, and also based on the information available from the structural evaluations. The notebooks recognized that there were two levels of inspection that would occur within the first thirty-six hours after a damaging earthquake. The first inspection, would be done immediately by the on site facility engineer. That inspection would be followed by a detailed inspection by a structural engineer who was scheduled to respond automatically to the medical center.

The notebook itself contained a detailed set of procedures to be followed in order to conduct the post-earthquake investigation, which included a series of forms and individualized posting placards. For each building that was determined to not meet the life-safety standards, the expected deficiencies were listed and noted on a set of architectural plans, so that they could be readily exposed and inspected in the event of a major earthquake. These notebooks formed the basis for training for the local facility engineers, healthcare providers and the structural engineers scheduled to respond immediately to the sites.

The inspection process supported by trained personnel and inspection notebooks provides a consistent source of information to the emergency operation center. A senior structural engineer is designated to be in the emergency operation center to communicate with both the facility engineers and structural engineering inspectors during the hours immediately following a damaging earthquake. This provides the second level of review and validation for the conditions observed, so that when recommendations are made to remain open or to evacuate a facility they carry a level of expert review and credibility.

As with any emergency preparedness activity, annual updating and training is necessary to keep the program viable. This California healthcare provider conducts at least annual exercises based on scenario events that are tailor made for their facilities. These scenario events are drawn from the information that is known about the various medical centers throughout California and the potential for damaging earthquakes. The use of actual building information and scenario earthquakes increases the usefulness of the training and brings it to a higher level of realism. It must be done, however, in a well-informed context so that the occupants of the building do not misinterpret the postulated damage.

Buildings that do not meet the minimum life-safety standards set by a building owner do not necessarily mean that the buildings are unsafe to occupy especially when they have been scheduled for rehabilitation. Training after the 1989 Loma Prieta earthquake focused on raising the level of awareness of the probability of occurrence of great earthquakes that would cause significant life-safety concerns as opposed to the probability of earthquakes that would need significant emergency response activity, but not be life threatening. While this is a hard concept to understand, people generally are willing to work in a building that does not meet the life safety standard once they understand the risk, and as long as there is a program to eliminate that risk in the future.

Monitoring to Ensure the Program Remains Current

Correcting seismic deficiencies for a inventory with hundreds of buildings located in dozens of sites throughout California is a long-term process. It is not uncommon for programs of this type to take twenty to thirty years to conclude. The length of time is required because of the extent of work that needs to be done, and the amount of planning and decision making that is necessary before significant dollars are spent in rehabilitation. The good news is the probability of an earthquake on any given year is very low, and in fact, time is on our side.

Because of the developing nature of earthquake engineering, every major earthquake brings new information and new techniques for understanding the performance characteristics of buildings. This information changes significantly every five to ten years. It is no surprise then that a long-term seismic mitigation program would need to adapt to new technologies and new understandings during the life of the program.

Anyone familiar with earthquake engineering and its development since 1971, knows that most of what is understood about the performance of buildings built prior to seismic design revisions has changed since that time. For this California healthcare provider, their concentrated program began after the development of ATC-14, but before the development the specific rehabilitation guidelines that are now available. With the experiences gained in the 1994 Northridge earthquake and 1995 Kobe earthquake, and with the development of new evaluation rehabilitation guidelines some aspects of the program needed to be refined.

In the last five years there have been three events that have caused significant changes in the corporate seismic hazard program. The Northridge earthquake signaled the significant vulnerability of modern California style parking garages and steel moment frame structures, illustrated the inadequacy of the hospital code to assure that non-structural elements would be available to service functioning hospitals, and triggered the SB1953 mandatory seismic upgrade program. This owner was presented with the information immediately after it became available and moved in a very methodical manner to adapt their program to the new information.

Amongst the variety of lessons that were learned in the Northridge earthquake was the recognition of the vulnerability of reinforced concrete parking garages. This class of construction had grown up to allow a combination of pre-cast and cast-in-place concrete structures with a discontinuous diaphragms that in all cases did not meet the most rigorous standards for structural analysis and detailing. A number of these structures collapsed in the earthquake and illustrated the need for a complete evaluation, complete structural analysis, and appropriate construction details. With respect to this California healthcare provider a reevaluation of all parking garages was commissioned. It was conducted in a three phase program. The first phase did a rapid screening to identify garages with potential deficiencies, the second phase conducted a detailed evaluation, and the third phase seismic strengthening of the garages. In all cases, these where garages that were judged to be satisfactory under the original seismic evaluation program. Fortunately, this client recognized that there was a change in understanding in the engineering profession, and moved to correct the apparent deficiencies.

Damage to steel moment frame structures that occurred in the Northridge earthquake caused an interesting series of events related to buildings that were under construction at the time of the earthquake. This California healthcare provider elected to continue constructing the buildings that were under construction and modify their new construction standards temporarily with a moratorium on steel frame construction until proper details of construction could be worked out. They determined that the cost of delaying current project far exceeded the cost of repairs that would be needed after a damaging event.

They have since returned to designing steel moment frame buildings with prescribed details. This experience brought to light the importance of moment frame construction in providing a facility that is most adaptable to new healthcare technologies. It was determined that such construction was worth the premium cost because of the needed flexibility.

The Northridge earthquake illustrated, in many locations, that the installation of non-structural elements including utilities systems, architectural systems, and building contents was not being done in a complete manner that permitted them to be as seismically resistant as was desired. It appeared that the fundamental problem was a lack of a design professional of record for these systems. In all cases, the structural bracing provisions for the systems were not part of the work of the structural engineer and were in most cases assigned to the contractor and the contractor's engineers. This proved to be unacceptable. This California healthcare provider elected to establish detailed requirements for the design, construction and inspection of all building systems and components so that there would be a higher level of reliability in the systems that were located in facilities that needed to remain functioning. They added a significant amount of design and inspection work to the design team to assure that the needed work was done. While these standards have caused additional costs to the projects and difficulty for the constructors and design professionals, they do address a fundamental problem that currently exists with building systems and their seismic performance.

The seismic mitigation program that has been underway since 1971 has been a voluntary program, and has focused on both the assurance that all facilities used by this California healthcare provider meet the minimum life-safety standards set by the corporation and achieve a reasonable level of functionality for all facilities. In 1998 such a program became law for all of California's hospitals. On the surface it appeared that the voluntary program put this provider many years ahead of other hospitals. However, there needed to be a refinement of the program so that it met the prescriptive requirements of the state mandate. This process is currently underway and will lead to the reevaluation of a variety of facilities and new economic analysis done for the viability of the various alternatives being considered.

To many design professionals, admitting that our earthquake engineering technology is emerging and that some of our previous decisions and recommendations need to be changed after five to ten years is quite threatening. There is a real concern that their clients will hold them liable for incomplete consulting when these changes are suggested. We have found with all of our clients that that is not the case. As long as there is a proper service oriented, client focused relationship in place, there is a automatic expectation that the newest information that comes along will be incorporated into the programs. It is in incumbent on the design professionals, when such information emerges, to inform their clients of the needed changes. This triggers a dialog about the significance of the changes and how they are best dealt with in the context of the business that is being effected. In some cases the changes represent a reduction in the expected reliability of systems, and the client may well choose accept the additional risk. In other cases, the changes may trigger a significant change in the expectations and the need to change the program and do remedial work. In both cases, open and rapid communication of changes is necessary to service client's needs and to preserve the client consultant relationship.

CONCLUSIONS

The seismic program described in this paper is unique in the healthcare industry for its' comprehensive nature, and for its' ability to incorporate lessons learned in recent earthquakes. A pro-active program such as this allows this healthcare provider to be well positioned to most effectively deal with the potentially disastrous impact that a major earthquake would have on the functionality and continuity of their numerous facilities. Many valuable lessons have been learned from this program that should be very useful to corporate administrators, planners, architects, and structural engineers that may face similar challenges. These include the value of preparedness, the usefulness of building evaluation data in many corporate programs, and the need to adapt the programs to new lessons learned with each major earthquake.

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