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Determining the necessary components of an Earthquake Preparation/Response Plan for the Park City Fire District

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Certification Statement

I hereby certify that this paper constitutes my own product, that where the language of others is set forth, quotation marks so indicate, and that appropriate credit is given where I have used the language, ideas, expressions, or writings of another.

Signed_____

Abstract

The Park City Fire District (PCFD) had not experienced a major earthquake in recent history; however, a risk analysis indicated that this type of event could have a profound and negative effect on the infrastructure and citizens of the district. It was deemed necessary for the PCFD to develop a formal fire agency-specific earthquake preparation/response plan that would address this hazard. The problem was that the PCFD had not determined the necessary components of a fire agency-specific preparation/response plan for major earthquakes. The purpose of this research was to determine the necessary components of a fire agency-specific earthquake preparation/response plan for the PCFD**.** The descriptive research method was used to determine how other fire organizations had addressed fire agency-specific earthquake planning, preparation, and response. Based on a review of the related literature, a survey mechanism was developed and distributed to a selection of fire agency representatives. The survey mechanism was intended to determine how other fire organizations had planned for an earthquake; and what actions these same organizations recommended in their formal earthquake plans/SOP's. It was determined that the majority of surveyed fire organizations support general and specialized earthquake training; earthquake-resistant fire stations; emergency generator installation; and food and water sustainment programs. In addition, most surveyed fire agencies have developed formal earthquake plans/SOP's that address post-incident protection of fire apparatus/equipment; communication plans; damage assessments of fire facilities; response communication guidance; damage assessments of first-in jurisdictions; incident prioritization; personnel safety; and outside resource utilization. Finally, it was recommended that the PCFD utilize the identified components to begin immediate pre-incident preparation and develop a formal SOP for post-incident fire district actions.

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Introduction

A large earthquake is likely the greatest natural disaster threat that the Park City Fire District (PCFD) is confronted with today. The impact of a devastating earthquake on citizens, infrastructures, economies, and emergency response agencies should not be underestimated. This type of event has a great potential to threaten lives, displace residents, and cause long-term challenges to the entire community.

History has proven that disaster planning can have a positive impact by improving overall incident preparation, response, and recovery. Based on the severity, probability, and consequences of a large earthquake in the Park City area, the PCFD leadership has determined that earthquake preparation should be a major district priority. It is common knowledge that formal emergency response plans and operational SOP's are considered the standard of care in the modern fire service. It also makes sense that these documents should be detailed, addressing major community target hazards and threats based on a thorough risk analysis.

Although the PCFD is currently included in state and local earthquake response plans, the PCFD does not have an internal plan to guide district preparation, response, and recovery to earthquake incidents. The PCFD leadership feels that this is an important step to better safeguard the residents and employees of the PCFD. The problem is that the PCFD has not determined the necessary components of a fire agency-specific preparation/response plan for major earthquakes.

The purpose of this research is to determine the necessary components of a fire agency-specific earthquake preparation/response plan for the PCFD. The descriptive research method will be used to answer the following questions. What pre-incident earthquake preparations have

other fire agencies initiated when planning for potential earthquakes? What fire agency-specific actions, not related to emergency response, have other fire organizations addressed in their agency plans/SOP's for earthquakes? What fire agency-specific public emergency response actions have other organizations included in their earthquake emergency response plans/SOP's? Along with a comparison of current literature, the evaluation of these research questions will determine the necessary components of a fire district-specific earthquake preparation/response plan for the PCFD; and eventually assist in the development and adoption of a formal plan/SOP.

Background and Significance

The PCFD provides fire, rescue, hazardous material, and medical response to Park City, UT and the surrounding unincorporated communities in Summit County. The PCFD staffs 26 full-time firefighters per day on a combination of trucks, engines, ambulances, and other specialty vehicles. Because of the large geographic area and multitude of specialty vehicles, PCFD employees are required to cross-staff various emergency response vehicles based on the nature of the incident. Based on this response configuration, the PCFD leadership has dedicated extensive resources and training to promote an all-risk hazard response which includes specialty training in collapse rescue, trench rescue, rope rescue, and confined space rescue. More recently in 2010, the PCFD was asked to be a participating agency in Utah Task Force 1(UTTF1) which is one of 28 federally sponsored urban search and rescue task forces managed by the Federal Emergency Management Agency (FEMA).

The PCFD's 110 square mile response area, located approximately 30 miles from metropolitan Salt Lake City, is a mix of residential, industrial, commercial, and semi-rural environments. Although the response district could be considered sparsely populated with approximately 32,000 full-time residents, a vibrant tourism industry provides an additional 4

million over-night visitors annually (Park City Fire District [PCFD], n.d.). In addition to the tourism industry, large numbers of workers and travelers pass through the district on Interstate 80 and Highway 40.

The PCFD jurisdiction is located approximately 30 miles from the Wasatch Front which includes the densely populated area of Salt Lake City and its surrounding communities. Along with this large population base, the Wasatch Front is home to the 240 mile long Wasatch Fault which has repeatedly experienced earthquake activities with a magnitude of 7 or larger. Specifically, the Wasatch Fault is made up of several segments that could severely damage gas, electric, water, communications, and transportation (United States Geological Survey [USGS], n.d.). Although scientists cannot accurately predict when an earthquake will occur, some believe that there is a 33% chance that a large earthquake will affect the Wasatch Front in the next 50 years (Foy, 2009). Perhaps most sobering is the possibility that an earthquake with a magnitude of 7 or larger could render thousands dead and tens of thousands injured (Utah Department of Public Safety [UDPS], 2011).

In 2009, the PCFD performed a risk analysis which identified earthquakes hazards as a significant risk to the residents, visitors, and infrastructure of the Park City area. Although it is not definitive as the extent of damage that a major earthquake would have on Park City in comparison to areas in Salt Lake City directly affected by the Wasatch Fault, the Summit County Emergency Operations Plan (EOP) states that “it should be assumed that the studies that have been completed in Salt Lake should have a direct influence on Summit County Planning” (p.9). Further validation on the potential risk of earthquake damage in the Park City area, can be found in Park City Municipal Corporation’s decision to spend approximately $10 million updating City Hall to current seismic standards (Science Daily, 2008). Confirming the PCFD risk assessment

results, the Park City Municipal Corporation identified earthquakes as a high risk, high priority event (Park City Municipal Corporation [PCMC], n.d.).

The results of the 2009 risk assessment in conjunction with current scientific data available suggest that the Park City area can be considered especially vulnerable to damage by earthquakes. The significance of these factors alone justifies research in regards to planning and response to earthquake events. The general responsibilities for disaster response are detailed in the Summit County Emergency Response Plan under Emergency Support Function (ESF) 4 for firefighting and ESF 9 for rescue. However, specific details on PCFD actions prior to and following an earthquake have been left to the discretion of district leadership. Currently the PCFD has no earthquake plan/SOP that specifies the actions of fire district personnel during and following an earthquake event. Perhaps most concerning is that, based on informal polling of PCFD officers, very few have any personal knowledge of appropriate response, actions, or county/state planning documents relevant to earthquake events. Ultimately, the lack of a PCFD-specific earthquake plan/SOP, especially given the consequences of a large earthquake in the Park City area, does not conform with the USFA's recommendation that local fire departments develop SOP's at the local level (USFA, 1999).

By examining the necessary components of an agency-specific earthquake plan/SOP, the PCFD can effectively develop a plan/SOP that will "improve the fire and emergency services' capability and response to and recovery from all hazards" and "improve local planning and preparedness") thereby supporting goal one and two of the USFA strategic initiatives (United States Fire Administration [USFA], n.d., p.13). Furthermore, the completed earthquake plan/SOP will provide the PCFD station officers with the knowledge and information that will allow them to utilize appropriate decision making skills in life threatening earthquake situations. As

discussed in unit four of the Executive Leadership Student Manual, a leader must have sufficient knowledge to ensure an effective decision when deciding alone. This form of decision making style allows the leader to make effective decisions, perhaps time sensitive, without discussing it with anyone (National Fire Academy [NFA], 2005).

Finally, the completed earthquake plan/SOP, based on the information ascertained in this research, will be evaluated in the spring of 2012 with a state-wide earthquake exercise. During the exercise, PCFD station officers will be expected to utilize the plan/SOP to perform necessary emergency actions.

Literature Review

The information presented in this literature review incorporates information relevant to preparation for earthquake emergencies, actions deemed appropriate during an earthquake, and emergency services response actions following an earthquake event. Information gleaned from searches of the local library, government publications, internet, and the National Fire Academy Learning Resource Center were utilized to identify major principles in earthquake preparation, response, safety, and recovery. Although general earthquake preparation and actions related to an earthquake event can be relevant regardless of affiliation with emergency services, the goal of this literature review is to focus on earthquake preparation, personnel actions, and emergency response tasks necessary for the fire service.

Earthquakes are caused by the sudden breaking and shifting of subterranean rock, resulting in ground shaking of the earth (Federal Emergency Management Agency [FEMA], 2011b). Although many natural disasters can be predicted with some advance notice, earthquakes offer little warning which makes pre-incident planning integral to maintaining essential emergency services (USFA, 2008). Further emphasizing the importance of pre-earthquake

planning, Perlman (2010) suggests that only a few seconds of advanced notice may be provided to earthquake victims, even with the most advanced earthquake warning systems. Fortunately, "Many, if not most, of the operational challenges that the fire service faces during disasters can be anticipated and planned for while there is time to resolve any policy issues that would arise concerning operating procedure" (USFA, 2008, p.1).

Preparation and response to emergencies is the basis for all fire service operations. Planning, coordination, and warning systems can help control all or parts of many emergencies (USFA, 2008). Although communities have no control over is their seismic hazard, one earthquake factor that can be controlled, and is probably the most important of all, is seismic retrofitting of existing structures at risk and enforcement of strict building codes (FEMA, 2011a). Based on the importance of building design for earthquake events, some fire departments are closing fire stations in order to ensure their firefighters are safe (Charles, 2011). In addition to seismic retrofitting and strict enforcement of building codes, FEMA(2011) also recommends repairing cracks in ceilings and foundations; securely anchoring overhead fixtures, shelves, mirrors, and other heavy objects; placing heavy items on lower shelves; securing hazardous materials in cabinets; repairing defective wiring and gas connections; and securing water heaters to the wall. The 8.8 magnitude Chilean earthquake of 2010 was a perfect demonstration of how strict building codes can greatly reduce losses in even the largest earthquakes, where over 350,000 housing units were destroyed as opposed to only five engineer-designed buildings (USGS, 2011). Finally, evidence of the importance of well-constructed building in conjunction with strictly enforced building codes, can be found in reduced casualty figures during California earthquakes (Shubin, 2009).

Although there may be only a few seconds of notice prior to an earthquake event as Perlman (2010) discussed, some departments have found that a few seconds of warning may be enough time for automated bay door opening systems to open the doors of apparatus bays and for people indoors to stop, drop, and cover. These special apparatus door openers and warning devices are activated by initial waves of an earthquake, which are not noticeable by humans (Sandoval, 2011). During the 1994 Northridge earthquake, structural damage caused many of the fire station apparatus doors to become jammed, requiring forcible exit before the units could respond on emergencies (USFA, 1997). Earthquakes have the potential to severely damage all levels of infrastructure, including power lines, power plants, buildings, roadways, pipelines, and all forms of structures (USFA, 2008). During the Chilean earthquake of 2010, much of the electricity was shut down shortly after the first earthquake in a successful attempt to limit the number of fires (USGS, 2011). This was ultimately the right decision, based on figures that show 60% of the fires following the last few California earthquakes were started by electrical problems (USGS, 2011). According to PCFD Fire Marshall Scott Adams, the International Code Council has mandated that all public safety buildings, including fire stations, police stations, etc., must be sustainable during times of disaster. A large part of this sustainability is the installation and maintenance of emergency generators. However, Chief Adams also points out that this, since this is not a retroactive standard, public safety buildings built before 2006 are not required comply (2011, personal communication, October 4, 2011). Finally, USFA (2008) has determined the necessity for all fire departments to prepare a plan that would assess losses, readiness, and assets of department fire stations following an earthquake.

Another way fire departments can plan for continued operations during major disasters is to maintain adequate supplies to support on-duty personnel for an extended period. This should

include operational equipment, portable cots, blankets, food, water, and adequate shelter (USFA, 2008). It is also recommended that members of fire departments reporting for extended hours of service bring a 3 day supply of toiletries, clothes, food, and non-perishable food items (USFA, 2008). In his research on Santa Rosa Fire Department (SRFD) earthquake preparations, Shubin (2011) found that only 10.3% of SRFD fire stations were equipped with three to five days of supplies, whereas 89.7% were not equipped with three to five days of supplies. However, Basset (2011) was unable to determine established guidelines on the amount of food, water, and bedding that a fire department should stockpile for each employee. A good example of preparation can be found in the Los Angeles County Fire Department (LACoFD), which supplies fire stations with enough food and water to ensure nonstop operations for extended periods (Collins, 2002).

Like all emergencies that fire departments are expected to respond to, earthquake emergencies may require organizations to provide specific training. Employee training on definitions of an earthquake, specifics of earthquake response, and identification/control of hazards involved in earthquake response are utilized to help workers become more aware of the basics earthquake emergency response (National Institute of Environmental Health Sciences [NIEHS], 2008). Based on the weaknesses in collapse rescue capabilities following several California earthquakes in the eighties, FEMA developed the national USAR system to assist fire agencies with collapse rescues and major entrapment situations following a large-scale disaster (Collins, 2002). When planning local emergency response capabilities, it is recommends that fire departments develop and provide ongoing commitment to specialized urban search and rescue teams within their organizations (Collins, 2002). Since earthquake emergencies are non-routine, they often require firefighters to perform a set of unique tasks; therefore it is imperative that agency-specific SOP’s are formulated for these situations (USFA, 1999). They also recommend

that fire organizations develop SOP's to train employees on the roles, assignments, and work requirements required during earthquakes and other disaster operations (USFA, 1999).

During an earthquake death and injury usually occurs from falling debris, collapsing walls, and flying glass caused by ground movement (Occupational Safety and Health Administration [OSHA], 2010). To increase safety during an earthquake, it is recommended that people drop to the ground; take cover; hold-on to something until the shaking stops; utilize doorways for protection if they are in close proximity; stay away from glass, windows, and outside walls; stay inside until the shaking stops; and not utilize elevators (FEMA, 2010).

Following an earthquake, the Los Angeles County Fire Department (LACFD) requires employees to perform a survey of personnel, equipment, and fire facilities within the first 15 minutes following an earthquake (Peninsula Volunteer Alert Network, n.d.). During the 1994 Northridge earthquake station officers assured the safety of their personnel; surveyed damage to the fire station, equipment, and apparatus; and then provided this information to the Battalion Commanders (USFA, 1994). More specifically, the Orange County Fire Authority (2005) earthquake response SOP dictates that fire station personnel assess for personal/crew injuries; move apparatus from the station if safe to do so; retrieve SCBA's, radios, and PPE from apparatus if unable to remove the vehicle from the station; evaluate station for damage and safety; shut off utilities; determine if auxiliary power is operating; determine if phones are functioning; and monitor radio traffic for a fire station roll call and status report. When the ground shaking stops, the OCFA (2005) requires all field Battalion Chiefs to contact the Emergency Command Center (ECC) by any means necessary, and advise the center of the actions they have selected based on their immediate assessment of the potential damage in their battalions.

Large-scale emergencies will often require more resources than normal staffing provides, therefore, fire departments must formulate plans to manage existing staffing, recall extra staffing, and maintain the staff that are present when the disaster occurred (USFA, 2008). To complicate issues, communication infrastructures can be destroyed (FEMA, 2011b). Even mobile communication devices may be rendered ineffective because of infrastructure damage, technical failures, or saturation of communication networks (Vervaeck, 2011). Also, without written policies on when personnel should report back to duty, where those personnel should report, and what actions they should take when they arrive, the callback response could create coordination, accountability, and ultimately safety issues (Collins, 2006). The SLCFD (2007) has eliminated some confusion by requiring all off-duty personnel to respond to their assigned stations only when there is a complete systemic communication failure. Additional information recommend for employees being recalled may be when, where, how long recall will last, what to bring, where family members can call for status check, and what conditions can be expected during recall period (USFA, 2008). To ensure mandatory holdover and recall of personnel during earthquake emergencies, the LACoFD requires all personnel "to sign a written agreement specifying that they will report to duty immediately after ensuring their family's safety and that they will remain at their posts until properly relieved, at which time they will check on their families and immediately return to duty" (Collins, 2002. ¶20).

Once personnel and equipment are evaluated, the daunting task of emergency response can be initiated. Large earthquakes can be extremely devastating; damaging buildings, transportation systems, power plants, water systems, and wastewater systems; igniting large fires; releasing hazardous materials; damaging electrical, water, sewer, and gas lines; and causing large-scale collapse of buildings and other structures (USFA, 2008). Because of this, "a

damage assessment is needed as soon as practical to assess the life safety needs and magnitude of the disaster. The preliminary damage assessment (PDA) scans the affected area to determine the width and breadth of damage in the initial phase" (Summit County, 2003. P.69).For the damage assessment process to be most effective, it is important that fire departments develop SOP's mandating that a jurisdictional survey be performed before emergency actions are taken, except to stop a potential conflagration or save a life (Collins, 2002). SLCFD (2007) recognizes the need to establish specific priorities during the damage assessment process; and recommends that fire companies give priority to schools, hospital, and rest homes. During the 1994 Northridge earthquake, damage assessment emphasis was placed on hospitals, fuel storage facilities, freeways, industrial facilities, and dams (USFA, 1994).

Following the preliminary damage assessment, a walk-through inspection of buildings should be performed in order to determine the extent of damage (Summit County, 2003). During earthquake events, it is likely that there will be catastrophic failure of structures requiring rescue personnel to assess structural stability, extinguish fires, shut off utilities, and provide building stabilization for the protection of rescuers and victims (OSHA, 2010). It is important to note that these types of emergencies pose extraordinary risks and challenges, therefore fire departments should utilize local and federal resources specially trained in urban search and rescue (Collins, 2002). Although search and rescue in collapsed concrete buildings requires specialized tools and urban search and rescue training, fire companies without specialized training and equipment may be able to perform many search and rescue missions in lightweight/wood frame structure collapse, especially if these companies are supervised by specialists in collapse rescue (Collins, 2002). Before structure collapse rescue operations can commence, a structural specialist should evaluate the structural condition of the area and determine the necessary precautions to protect

victims and rescuers (OSHA, 2010). Company officers should be instructed on the recognition of situations that may require specialty resources and these resources must be requested early in the incident to be most effective (Collins, 2002). Finally, since natural disasters can be large in scale, require massive amounts of resources, and last for extended time periods, it is essential that fire departments identify specialty and mutual-aid resources before an incident; thus enabling a more coordinated and legal effort (USFA, 2008).

In summary, Shubin (2009) found that public education, strict building codes, community preparedness, and emergency food/water supplies are essential components that should be considered when developing an earthquake preparedness plan. In addition, Collins (2002) effectively summarized the importance of incident prioritization, uninterrupted damage assessments except in life safety situations, specialized resources, mandatory callback/holdover policies, and structure triage. Overall, the literature review provided an extensive knowledge base applicable to the research questions; and ultimately helped provide focus to the applied research, eliminating information that is likely unnecessary in a fire-serviced based earthquake plan/SOP.

Procedures

The first step in the applied research process was to develop a knowledge base on earthquake dynamics, preparation, and emergency response. This was done through a review of books, technical documents, websites, magazine articles, and interviews. Following a review of the emergency response planning documents that the PCFD currently utilizes, it was decided that the applied research would focus only on fire-agency specific earthquake planning, actions, and response as other planning documents were vague and unspecific in nature.

The next step in the research process was to determine a focus group that would provide the most relevant data on fire-agency earthquake planning, preparation, personnel actions, and response. The first focus group included approximately 20 fire chiefs from Utah. This Utah-based focus group was included to gain a local perspective on the earthquake plans/SOP's of other fire departments that are faced with very similar hazards, demographics, and challenges. The second focus group was approximately 80 participants from the Executive Fire Officer Program at the NFA. The intent of this focus group was to provide research data of a more global perspective.

After developing knowledge on the subject matter and establishing a focus group, a survey mechanism was developed based on the reviewed literature and past experience of the author. Since the intent of the survey mechanism and research was to focus evaluation on planning, actions, and response relative to earthquake emergencies; the first question of the survey instrument in *Appendix A* was designed to eliminate responses from all fire agencies in which earthquakes were not a significant hazard. It was thought that if this segment of the focus group was eliminated, that the accuracy of the data would be enhanced.

The first research question regarding the pre-incident earthquake preparation that other fire agencies have initiated when preparing for a potential earthquake, was addressed with question number three from the survey instrument found in *Appendix A.* Literature, past experience, and common sense established that effective earthquake preparation may require specialized training; well-built public safety buildings; earthquake-specific safety practices; and stockpiling of food, water, and supplies. However, it was hoped that the data gleaned from the practices of other fire agencies would confirm the importance of these factors.

The second research question regarding the fire agency –specific actions, not related to emergency response, that other fire agencies have addressed in their agency earthquake plans/SOP's was evaluated with question number two and four of the survey instrument found in *Appendix A.* Question number two of the survey instrument asked whether or not the respondents utilized fire agency-specific earthquake plans/SOP's. Since the intent of the second research question was to determine only fire-agency specific actions that had been included in written agency-specific plans/SOP's, this survey instrument question was designed to further narrow the focus field. It is assumed that members of the survey group that responded that they did not have written fire agency-specific plans/SOP's in survey question number two, would not answer survey instrument question number four, regarding earthquake actions included in agency-specific plans. Review of applicable literature and past experience provided the basis for survey question number four found in *Appendix A.* The intent of this survey question was to confirm which actions that organizations had included in their fire agency-specific earthquake plans/SOP's in comparison to the available literature and past knowledge of the author. In addition to the choices provided, the question allowed the respondent to include other actions that their organization may have included in their agency-based earthquake plans/SOP's. This option was provided with the intent of gaining insight and information that was not discovered through literature review. A limitation of this research is that the survey instrument was specific to earthquake plans/SOP's, whereas some agencies may include certain earthquake-related actions, like holdover/callback, in other agency SOP's.

The final research question on the fire agency-specific public emergency response actions that other organizations have included their earthquake emergency response plans/SOP's was evaluated using question number five form the survey instrument in *Appendix A.* Based on

knowledge gained from literature review and case studies, it was determined that fire organizations may include damage assessment, incident prioritization, target hazards, emergency communications, personnel safety, building triage, fire suppression specific to earthquake response, and outside resource utilization in their formal organizational earthquake plans/SOP's. Survey question five also allowed respondents to add additional actions that their organizational earthquake plans/SOP's included. The intent of this survey question was to evaluate which emergency response actions that organizations had included in their agency earthquake plans/SOP's, compared to what the available literature recommended.

The final step in the procedural process was to send out the survey instruments via e-mail. In September 2011, the 100 instruments were sent out to the two focus groups described earlier, with limited instructions on completing the survey. Approximately two weeks were allowed before surveys were gathered and analyzed. Surveys were collected and analyzed in October with the data included in the results section.

Results

Of the 100 potential survey participants that were contacted, 14 responded within the two week period. Five of the 14 that responded only completed question number one from the survey instrument found in *Appendix A*, and were excluded from the remainder of the survey based on the fact that earthquakes were not a significant hazard in their jurisdiction. The remaining nine respondents completed all of the survey questions with their responses summarized in the following paragraphs. Although this response was less than expected, in comparison to previous research requests for other projects, the data gathered ultimately represents a varied cross-section of fire departments. More importantly, the data compiled represents fire organizations that have

the potential of large earthquake events, and is not tainted by responses of organizations that need not prepare for this type of event.

To answer the first research question on which pre-incident earth quake preparations other fire organizations have initiated during preparation for potential earthquakes, survey question number three, found in *Appendix A,* was analyzed. The evaluation results, found in *Appendix B,* show that 77.8% of respondent organizations have planned for earthquake events by incorporating general personnel training specific to earthquakes, assessing and upgrading fire stations to current building codes related to earthquake resistance, and installing emergency generators in fire stations. Fire agencies that have implemented programs to stock/maintain supplies, food, and water comprised 55.6% of the respondents. Fire agencies that have evaluated station safety concerns as they relate to earthquakes and implemented specialized training specific to earthquakes (collapse rescue, etc.) made up 44.4% of the respondents. Finally, only 11.1% of respondents had installed emergency bay door openers in fire stations. In summary, the majority of fire departments surveyed have incorporated general personnel training specific to earthquakes, assessed and upgraded fire stations to current earthquake-resistant building standards, and implemented programs to stock/maintain supplies, food, and water. Furthermore, most fire departments surveyed have not implemented specialty training programs specific to earthquakes, evaluated fire station safety concerns as they relate to earthquakes, or installed emergency bay door openers in their fire stations.

The second research question on fire agency-specific actions, not related to emergency response, that other organizations have addressed in their agency earthquake plans/SOP's was evaluated with survey question number four from the survey instrument found in *Appendix A.* Evaluation of survey responses found in *Appendix C,* shows that out of all agency-specific

earthquake plans/SOP's of surveyed organizations, 87.5% include actions to protect fire apparatus/equipment during and immediately following an earthquake, 75% include communication actions with fire headquarters and/or dispatch, 62.5% include detailed damage assessment of fire service buildings and infrastructure, 25% include actions to protect personnel in the fire station during an earthquake, 25% include direction on automatic response of off-duty personnel, 25% include direction on mandatory holdover of on-duty personnel, and no respondents indicated that their earthquake plans/SOP's included any further options not listed on the survey instrument. Overall, a large percentage of surveyed fire agencies include actions to protect apparatus/equipment, communication instructions, and instructions on damage assessment of fire service buildings/infrastructure, in their fire agency-specific earthquake plans/SOP's. Whereas, very few surveyed organizations include actions to protect personnel in the fire station, direction on automatic off-duty response, or direction on mandatory holdover, in their agency-specific earthquake plans/SOP's.

To answer the final research question, concerning the fire agency-specific public emergency response actions that other organizations have included in their earthquake emergency response plans/SOP's, question number five from *Appendix A* was utilized. The results, shown in *Appendix D,* indicate that of the fire departments surveyed, 100% include emergency communications actions, 77.8% include damage assessment actions, 77.8% include target hazard priorities, 66.7% include incident prioritization actions, 55.6% include personnel safety actions, 55.6% include outside resource utilization, 44.4% include building triage actions, and 11.1% include fire suppression specific to earth quakes, in their agency-specific earthquake plans/SOP's. In addition, none of the respondents indicated that their agency-based earthquake plans/SOP's included any other actions that were not displayed in the survey question. In short,

the majority of surveyed agency earthquake plans/SOP's include guidance on emergency communications, damage assessment, target hazard priorities, incident prioritization, personnel safety, and outside resource utilization. Whereas, most surveyed agencies did not provide guidance on resource allocation, building triage actions, or fire suppression actions specific to earthquakes, in their organizational plans/SOP's for earthquake emergency response.

Discussion

Results for the first research question on earthquake preparation showed that 77.8% of surveyed organizations have planned for earthquake events by incorporating general personnel training specific to earthquakes. Reviewed literature also points to the importance of incorporating additional skill sets related to earthquakes. Employee training on definitions of an earthquake, specifics of earthquake response, and identification/control of hazards involved in earthquake response are utilized to help workers become more aware of the basics earthquake emergency response (National Institute of Environmental Health Sciences [NIEHS], 2008).Since earthquake emergencies are non-routine, they often require firefighters to perform a set of unique tasks; therefore it is imperative that agency-specific SOP's are formulated for these situations (USFA, 1999). Finally, the USFA (1999) recommends that fire organizations develop SOP's to train employees on the roles, assignments, and work requirements required during earthquakes and other disaster operations. Ultimately, it is not surprising that both applied research and literature place great emphasis on earthquake-specific training. In contrast, only 44.8% of organizations surveyed have implemented specialized training (collapse rescue, etc.) specific to earthquake response. This lack of specialized training by surveyed organizations contradicts recommendations that fire departments develop and provide ongoing commitment to specialized urban search and rescue teams within their organizations (Collins, 2002). The importance of this

specialized training is ultimately demonstrated in FEMA's development of the national USAR system to assist fire agencies with collapse rescues and major entrapment situations, which was based on the weaknesses in collapse rescue capabilities following several California earthquakes in the eighties (Collins, 2002).

Research found that 77.8% of surveyed fire agencies have performed assessments and upgrades of fire stations to current earthquake-resistant building standards. The importance of well-built structures was emphasized throughout the literature review. One earthquake factor that can be controlled, and is probably the most important of all, is seismic retrofitting of existing structures at risk and enforcement of strict building codes (FEMA, 2011a). Finally, evidence of the importance of well-constructed building in conjunction with strictly enforced building codes, can be found in reduced casualty figures during California earthquakes (Shubin, 2009). Overall, both literature and applied research demonstrate the importance of earthquake-resistant buildings for fire stations and other structures. In addition to earthquake-resistance, PCFD Fire Marshall Scott Adams (personal communication, October 4, 2011) advised, that the International Code Council has mandated that all public safety buildings, including fire stations, police stations, etc., be sustainable during times of disaster. A large part of this sustainability is the installation and maintenance of emergency generators. However, Chief Adams (personal communication, October 4, 2011) also points out that since this is not a retroactive standard, public safety buildings built before 2006 are not required comply. Confirming the importance of fire station sustainability, 77.8% of fire agencies surveyed had installed emergency generators in their fire stations. However, research did not determine whether the generators were retrofitted into older fire stations or installed in post-2006 fire stations that were required to include these devices by

code. In short, research and literature both place a large emphasis on earthquake-resistant construction and sustainability of fire stations.

Survey participants placed some emphasis on maintaining supplies, food, and water in fire stations with 55.6% responding that their agencies utilized plans to do so. The percentage of fire agencies that supply stations with food and water was higher than some other studies done. In his research on SRFD earthquake preparations, Shubin (2009) found that only 10.3% of SRFD fire stations were equipped with three to five days of supplies. However, the fact that only 55.6% of departments in this study maintain programs to stock emergency supplies, does not wholly comply with FEMA's recommendation that operational equipment, portable cots, blankets, food, water, and adequate shelter be provided to support on-duty personnel for extended operations (FEMA, 2008). Fire departments that are very susceptible to earthquakes, like LACoFD, serve as a great example by supplying fire stations with enough food and water to ensure nonstop operations for extended periods (Collins, 2002). Ultimately, literature stressed the importance of fire station food and water caches and most fire departments researched in the project maintained plans to do so, confirming the importance of this planning practice.

The evaluation of fire station safety concerns as they relate to earthquakes and the installation of emergency apparatus bay door openers were not accomplished by most agencies surveyed. In contrast, FEMA (2011) recommends repairing cracks in ceilings and foundations; securely anchoring overhead fixtures, shelves, mirrors, and other heavy objects; placing heavy items on lower shelves; securing hazardous materials in cabinets; repairing defective wiring and gas connections; and securing water heaters to the wall. This recommendation and common sense dictate that these practices would be helpful, despite of the lack of popularity with surveyed fire agencies. It is not surprising that only 11.1% of responding agencies have installed

emergency apparatus bay door openers. This new technology relies on special sensors, triggered by initial waves of an earthquake not noticeable by humans, to activate automatic door openers (Sandoval, 2011). Based on events during the 1994 Northridge earthquake, where structural damage caused many of the fire station apparatus doors to become jammed, requiring forcible exit before the units could respond on emergencies (USFA, 1997), these devices may be considered a viable option but applied research does not indicate this.

In summarizing the supporting data of research question number one, regarding the pre-incident preparations that other fire organizations have considered when preparing for a potential earthquake, it is evident through research and literature that fire organizations should provide their employees with earthquake specific training, upgrade fire stations to be earthquake-resistant, retrofit/build fire stations to be sustainable during a disaster, and maintain supplies of food and water that will support extended operational periods. Although literature review recommended that specialized earthquake training and evaluation of station safety concerns were important aspects of earthquake planning, research did not confirm this importance. However, common sense and past experience in conjunction with the available literature may validate these practices. Finally, based on literature review and applied research, installation of emergency bay door openers is the lowest priority of all components of earthquake planning studied.

Results for the second research question on fire agency-specific actions, not related to emergency response, that other fire organizations have addressed in their agency earthquake plans/SOP's, indicate that 87.9% of all surveyed fire agency earthquake plans/SOP's recommend protective action for fire apparatus/equipment following an initial earthquake event. Confirming the survey results, the OCFA (2005) earthquake response SOP dictates that fire station personnel

assess for personal/crew injuries; move apparatus from the station if safe to do so; and retrieve SCBA's, radios, and PPE from apparatus if unable to remove the vehicle from the station.

Research also indicates that most departments have included instructions on communications with headquarters/dispatch (75% of those surveyed) and detailed damage assessment of fire service buildings and infrastructure (62.5% of those surveyed), in their agency earthquake plans/SOP's. In support of these research results, the LACFD requires employees to perform a survey of personnel, equipment, and fire facilities within the first 15 minutes following an earthquake (Peninsula Volunteer Alert Network, n.d.). More specifically, the OCFA (2005) earthquake response SOP dictates that fire station personnel assess for personal/crew injuries and monitor radio traffic for a fire station roll call/status report. In addition, during the 1994 Northridge earthquake station officers assured the safety of their personnel; surveyed damage to the fire station, equipment, and apparatus; and then provided this information to the Battalion Commanders (USFA, 1994). Overall, research and available literature overwhelmingly support the inclusion of fire station/infrastructure damage assessments and instructions for post-earthquake communications in agency earthquake plans/SOP's.

Finally, only 25% of surveyed fire agency earthquake plans/SOP's include actions to protect personnel in the fire station, automatic response of off-duty personnel, and mandatory holdover of on-duty personnel. The lack of personnel protective actions in agency earthquake plans/SOP's may be attributed to the belief that these actions are well-published in other public and private earthquake documents. To increase safety during an earthquake, it is recommended that people drop to the ground; take cover; hold-on to something until the shaking stops; utilize doorways for protection if they are in close proximity; stay away from glass, windows, and outside walls; stay inside until the shaking stops; and not utilize elevators (FEMA, 2010). Based

on the availability of this information to the public as a whole, inclusion of personnel protective actions may not be completely necessary in agency earthquake plans/SOP's. However, its inclusion would ensure that employees are aware of these common practices, regardless of their experience and/or education outside of the fire agency.

Although research indicated that only 25% of surveyed fire agencies include automatic response of off-duty personnel and mandatory holdover of on-duty personnel in their agency earthquake plans/SOP's, their importance is well documented in literature. Because large-scale emergencies will often require more resources than normal staffing provides, fire departments must formulate plans to manage existing staffing, recall extra staffing, and maintain the staff that are present when the disaster occurs (USFA, 2008). Furthermore, without written policies on when personnel should report back to duty, where those personnel should report, and what actions they should take when they arrive, the callback response could create coordination, accountability, and ultimately safety issues (Collins, 2006).Finally, to ensure mandatory holdover and recall of personnel during earthquake emergencies, the LACoFD requires all personnel "to sign a written agreement specifying that they will report to duty immediately after ensuring their family's safety and that they will remain at their posts until properly relieved, at which time they will check on their families and immediately return to duty" (Collins, 2002, ¶20). In spite of the results of this research, literature places a great emphasis on inclusion of callback/holdover actions in agency earthquake and disaster plans. As noted in the procedures section of this paper, the accuracy of this response may be limited, as some of the surveyed agencies may have separate callback/holdover SOP's and their inclusion in an agency earthquake plan/SOP was determined to be redundant. Ultimately, based on literature and contrary to the

results of the research, the author feels strongly that callback/holdover actions are vital components of an earthquake plan/SOP.

In summary, research and literature indicate that protection of fire apparatus/equipment; post-earthquake communication guidance, including roll call of personnel; and damage assessment guidance should be major components of a fire agency earthquake plan/SOP. In addition, although research did not reflect the importance of mandatory callback/holdover following earthquake events, the available literature more than validates their importance as components in a fire agency-based earthquake plan/SOP.

Results for the final research question, regarding the fire agency-specific public emergency response actions that other organizations have included in their earthquake emergency response plans/SOP's, indicated that the majority of fire agencies include emergency communications, damage assessment, target hazard priorities, incident prioritization (interruption of damage assessment for life safety/rescue), personnel safety, and outside resource utilization (public and private)in agency plans/SOP's. Much of the reviewed literature supports these findings. Based on research and literature, the importance of emergency communication should not be underestimated. During earthquakes, communication infrastructures can be destroyed (FEMA, 2011b). Even mobile communication devices may be rendered ineffective because of infrastructure damage, technical failures, or saturation of communication networks (Vervaeck, 2011). The likelihood that both fixed and wireless communication can be destroyed is enough reason to include concessions for these events in agency earthquake plans/SOP's. Research confirmed the need to include emergency communication actions in agency plans/SOP's with 100% of surveyed organizations including them.

Surveyed agencies also believed that damage assessment and target hazard priorities were important enough to include in their agency earthquake plans/SOP's. Literature ultimately validates the 77.8% of surveyed agencies that choose to include these actions in their earthquake plans/SOP's. Large earthquakes can be extremely devastating, damaging buildings, transportation systems, power plants, water systems, and wastewater systems; igniting large fires; releasing hazardous materials; damaging electrical, water, sewer, and gas lines; and causing large-scale collapse of building and other structures (USFA, 2008).Because of this, "a damage assessment is needed as soon as practical to assess the life safety needs and magnitude of the disaster. The preliminary damage assessment (PDA) scans the affected area to determine the width and breadth of damage in the initial phase" (Summit County, 2003. P.69). It is evident that both surveyed agencies and current literature feel that damage assessments are important response actions, therefore, it makes sense that actions this vital to earthquake response be included in agency earthquake plans/SOP's. In addition to including damage assessments in agency plans/SOP's, literature and research also support prioritizing the damage assessment process. SLCFD (2007) recognizes the need to establish specific priorities during the damage assessment process and recommends that fire companies give priority to schools, hospital, and rest homes. During the 1994 Northridge earthquake, damage assessment emphasis was placed on hospital, fuel storage facilities, freeways, industrial facilities, and dams (USFA, 1994).

Guidance on incident prioritization (interruption of damage assessment for life safety/rescue), personnel safety, and outside resource utilization (public and private) were all included in over 55% of surveyed fire agency earthquake plans/SOP's. Similar importance is illustrated in reviewed literature. For the damage assessment process to be most effective, it is important that fire departments develop SOP's mandating that a jurisdictional survey be

performed before emergency actions are taken, except to stop a potential conflagration or save a life (Collins, 2002). Supporting the majority of respondents that included information on outside resource utilization, the reviewed literature indicated that company officers should be instructed on the recognition of situations that may require specialty resources and these resources must be requested early in the incident to be most effective (Collins, 2002). In addition, since natural disasters can be large in scale, require massive amounts of resources, and last for extended time periods, it is essential that fire departments identify specialty and mutual-aid resources before an incident; thus enabling a more coordinated and legal effort (USFA, 2008).. Finally, the fact that most surveyed department included personnel safety actions in their agency earthquake plans/SOP's is consistent with fire service culture in general. Although no specific literature on the safety of personnel was reviewed, most of the actions recommended in the literature directly promote the safety of responders and victims.

Most surveyed fire agencies do not include actions for building triage or fire suppression specific to earthquake response in their agency earthquake plans/SOP's. However, before structure collapse rescue operations can commence, a Structural Specialist should evaluate the structural condition of the area and determine the necessary precautions to protect victims and rescuers (OSHA, 2010). The failure of the majority of fire departments to include building triage actions in agency-specific plans/SOP's may be attributed to the fact that very specialized training, usually in building engineering, is often required to make these decisions. Fire suppression specific to earthquake response is included in very few surveyed agency plans/SOP's. However, it is clear from literature that fire departments should develop SOP's mandating that a jurisdictional survey be performed before emergency actions are taken, except to stop a potential conflagration or save a life (Collins, 2002). Thus, since actual fire fighting is

similar in many situations, the prioritization of when crews should stop and fight fires may very well be the most important aspect. Again, it should also be noted that the majority of surveyed fire agencies did include incident prioritization guidance in their earthquake plans/SOP's.

In summary, both survey and literature indicate that agency earthquake plans/SOP's should included guidance on emergency communication, damage assessment, incident prioritization, personnel safety, and outside resource utilization. Based on these findings, it is clear that these components are integral to a comprehensive earthquake plan/SOP for the PCFD.

Recommendations

To determine the necessary components of a fire agency-specific earthquake preparation/response plan for the PCFD, it was necessary to address both current literature and common practices of other fire agencies. Research and literature review has provided the background for the PCFD to begin proper planning and preparation for a future earthquake event. In addition, the project provided new information and validated current fire agency practices necessary for the development of an agency-based earthquake response plan/SOP for the PCFD.

Based on information gained through a comparison of literature review and the practices of other fire agencies, it is imperative that the PCFD begin earthquake planning and preparation immediately. Current literature, validated by the preceding research, indicates that the PCFD leadership should begin the earthquake preparation process by performing an audit on all occupied buildings within the district. This audit should be based on the earthquake resistance of PCFD structures and other safety concerns (high storage, mounted overhead equipment, etc.) that may become hazards during an earthquake event. The results should be forwarded to PCFD logistic personnel for follow up and/or repair. Fortunately, the PCFD occupies relatively new

structures which may limit the overall cost compared to many agencies. Also, in accordance with research and literature, PCFD logistics personnel should begin stocking food and water supplies in each fire station. In order to support extended operations following a major earthquake, these supplies should be sufficient to support all 78 employees for at least 72 hours or longer.

Following initiation of the fire station safety audit and the station supply program, the PCFD training division should coordinate general earthquake training for all employees of the district. This training should incorporate actions to take during an earthquake emergency, particularly how to stay safe during an earthquake. Fortunately, the PCFD has already begun specialized training relevant to earthquake response with several of the PCFD employees attending the FEMA structural collapse technician course. This training of local responders will be invaluable during an earthquake event.

Research and literature review identified several key, non-emergency response, components that should be included in an earthquake response SOP. The key non-emergency response components that should be included in a PCFD earthquake SOP are actions to protect fire apparatus/equipment/ during and immediately following an earthquake; communication guidance including personnel roll call following an earthquake; and procedures on damage assessment of PCFD infrastructure following an earthquake. Although research did not support including callback/holdover guidance in earthquake SOP's, reviewed literature and past experience dictate their inclusion in the newly formed PCFD earthquake SOP.

In addition to the non-emergency response actions necessary, research and literature suggest that emergency communication guidance, damage assessment, target hazard prioritization, incident prioritization (interruption of damage assessment for life safety/rescue),

personnel safety guidance, and outside resource utilization are necessary components; and should be included in a PCFD earthquake SOP.

The PCFD earthquake response SOP should be drafted by the PCFD operational chiefs and approved by the PCFD fire chief. Upon completion, the PCFD training officer should deliver training on all aspects of the SOP to district personnel. Finally, in the spring of 2012, members of the PCFD should “exercise” the PCFD earthquake SOP during the statewide drill that is currently being planned. Following the statewide drill, operations chiefs and the training officer from the PCFD should evaluate the effectiveness of the SOP and make necessary changes based on their findings.

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Appendix A

Fire Service Survey Instrument

1. Are earthquakes a significant hazard in your jurisdiction?
    a. Yes
    b. No (If you answered no, your survey is complete)

2. Has your organization developed fire agency-specific plans/SOP's for personnel guidance during and following an earthquake event?
    a. Yes
    b. No

3. Which of the following pre-incident earthquake preparations has your department initiated? (choose all that apply)
    a. General personnel training specific to earthquake incidents
    b. Specialized personnel training specific to earthquake incidents (collapse rescue, etc.)
    c. Assessment and upgrades of fire stations to current building codes related to earthquake resistance
    d. Evaluations of station safety concerns as they relate to earthquakes (equipment mounting, high storage, etc.)
    e. Installation of emergency generators at fire stations
    f. Installation of emergency apparatus bay door openers in fire stations
    g. Programs to stock/maintain food and water supplies at the fire station

4. Which fire organization-specific actions, not related to emergency response, has your organization addressed in agency-specific plans/SOP's for earthquakes? (choose all that apply)
    a. Actions to protect personnel in the fire station during an earthquake
    b. Actions to protect fire apparatus/equipment during and immediately following an earthquake
    c. Detailed damage assessment of fire service buildings and infrastructure
    d. Automatic response of off-duty personnel
    e. Mandatory holdover of on-duty personnel
    f. Communication with fire headquarters and/or dispatch
    g. Other (please specify)

5. Which fire organization-specific public emergency response actions following an earthquake do your agency-specific plans/SOP's address?
    a. Damage assessment
    b. Target hazard priorities
    c. Incident prioritization (interruption of damage assessment for life safety)
    d. Emergency communication options
    e. Personnel safety
    f. Building triage

g. Fire suppression specific to earthquake response
h. Outside resource utilization (public and private)
i. Other (please specify)

Appendix B

Fire Agency Pre-incident Earthquake Planning

Pre-incident earthquake planning component	% of agencies implementing component
General personnel training specific to earthquakes	77.8%
Assessment and upgrades of fire stations to current building codes related to earthquake resistance	77.8%
Installation of emergency generators in fire stations	77.8%
Programs to stock/maintain supplies, food, and water	55.6%
Specialized personnel training specific to earthquake response (collapse rescue, etc.)	44.4%
Evaluation of station safety concerns as they relate to earthquakes (equipment mounting, elevated storage, etc.)	44.4%
Installation of emergency bay door openers in fire stations	11.1%

Appendix C

Fire Agency Non-emergency Response Actions

Fire agency non-emergency response action	% of organizations incorporating action into agency earthquake plan/SOP
Actions to protect fire apparatus/equipment during and immediately following an earthquake	87.5%
Communication with fire headquarters and/or dispatch	75%
Detailed damage assessment of fire service buildings and infrastructure	62.5%
Actions to protect personnel in the fire station during an earthquake	25.0%
Automatic response of off-duty personnel	25.0%
Mandatory holdover of on-duty personnel	25.0%
Other (respondent was asked to specify)	0.0%

Appendix D

Fire Agency Emergency Response Actions

Fire agency emergency response action	% of organizations incorporating action into agency earthquake plan/SOP
Emergency communication options	100.0%
Damage assessment	77.8%
Target hazard priorities	77.8%
Incident prioritization (interruption of damage assessment for life safety/rescue)	66.7%
Personnel safety	55.6%
Outside resource utilization (public and private)	55.6%
Building triage	44.4%
Fire suppression specific to earthquake response	11.1%
Other (respondent was asked to specify)	0.0%