MODEL PROGRAM FOR CONSTRUCTION CRISIS AND DISASTER MANAGEMENT

By

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A THESIS PRESENTED TO THE GRADUATE SCHOOL
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To my parents
For their constant encouragement and support throughout my life.

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Today, the United States and many parts of the world are at significant risk of natural and man-made disasters. Hazards are naturally occurring or man-made phenomenon that may result in disaster when occurring in a populated, commercial or industrial area. Although there is no system in either the private or public sector for consistently compiling comprehensive disaster costs, conservative estimates indicate a cost of at least $20 billion annually in loss of life and property, disruption of commerce and recovery. The rationale of this study is to provide an overview of the hazard risks facing or potentially facing construction projects and to review the current efforts to improve the disaster resiliency, as well as present a model that can serve as a guide for addressing disaster that might impact a construction project.

Extreme weather events, hurricanes, flooding, tornadoes, drought, wildfires, earthquakes, volcanoes, landslides and disease epidemics are some natural challenges at the macro level that can adversely impact a construction project. Disasters including critical infrastructure threats, oil and chemical spills, building fires, falls, and cave-ins are examples of man-made disasters that may need to be addressed. The work of OSHA is inadequate to address many of the problems that might occur. Although, the Federal Emergency Management Agency (FEMA) is working

for the cause in reducing the adverse impact of disasters at the national level, much needs to be done for the emergency control and disaster mitigation on construction projects. Emergency management is the process by which all individuals, groups, and communities manage hazards in an effort to avoid or ameliorate the damage resulting from crisis/disaster events. Actions taken depend in part on the perceptions of risk of those exposed.

The research carefully analyzed the crisis/disaster identification, risk assessment, risk communication, mitigation, prediction and preparedness for the construction industry in the times of natural and man-made crises/disasters. The model generated could be helpful in the preventative and reactive measures exercised when disasters are a possibility or after they have occurred. Thus, the research would enhance the decision making capabilities of construction managers during the sensitive crisis/disaster phases.

CHAPTER 1
INTRODUCTION

The US economy is adversely affected each year by weather and climate events. Between 1980 and 2002, the U.S. endured 54 weather-related crises/disasters in which overall damages and costs reached or exceeded $1 billion per event. Of these crises/disasters, 45 occurred during the 1988-2002 period with total damages and related costs of nearly $200 billion.

Hazards are naturally occurring or human-made phenomenon that may result in crisis/disaster, especially when occurring in populated, commercial or industrial areas. Although there is no established system or mechanism for compiling comprehensive crisis/disaster costs, conservative estimates indicate that $20 billion is lost annually in terms of loss of life and damaged property, disruption of commerce, and costs of recovery.

Extreme weather events, hurricanes, flooding, tornadoes, drought, wildfires, earthquakes, volcanoes, landslides and disease epidemics are examples of some large-scale challenges that may be envisioned. Man-made crises/disasters including critical infrastructure threats, oil and chemical spills, building fires, falls, and cave-ins are examples of a few activities that may also result in costly losses. The work of the Occupational Safety and Health Administration (OSHA) is inadequate to properly address many of the problems that may occur. Although the Federal Emergency Management Agency (FEMA) was established to address crises/disasters at the national level, more needs to be done for emergency control and crisis/disaster mitigation. Emergency management is the process by which all individuals, groups, companies and communities manage hazards in an effort to avoid or ameliorate the impact of crises/disasters. Actions taken depend in part on perceptions of the risks of those exposed.

Managers of construction recognize that many types of natural and man-made crises/disasters can be experienced on construction projects. The ultimate impact of crisis/disaster on a construction project can be severe. These impacts may be reduced or minimized if an effective program is implemented. Such a program will include steps taken to prepare for crises/disasters, as well as efforts to efficiently and systematically recover from them.

Aim and objectives. One of the characteristics of crises/disasters is that their occurrence is uncertain or irregular, and this requires special attention from the impacted individuals, companies and communities due to their potential vastness of the resultant damage. Crises/disasters that may need to be addressed include the following:

- Extreme weather events, including hurricanes, flooding, tornadoes, and drought
- Wildfires
- Earthquakes, volcanoes, and landslides
- Disease epidemics
- Man-made crises/disasters, including critical infrastructure threats, oil and chemical spills, and building fires
- Falls
- Heavy machinery accidents
- Small tools emergencies
- Cave-in events
- Plant or animal related incidents
- Terrorists’ attacks on construction sites
- Jobsite violence

Crisis/disaster planning, emergency preparedness, or business continuity (different terms for the related theme) have goals that are ultimately the same: to get an organization back up and running in the event of an interruption resulting from a crisis/disaster. The problem causing the interruption could be one machine that was mishandled or an entire network crashing. It could also be an electrical outage or damage resulting from terrorist activity. The goal is to have some type of plan in the event of a problem. A crisis/disaster management plan will outline the basic procedures to be followed to minimize the adverse impact of the crisis/disaster.

The study will provide an overview of several risks facing construction projects, review the efforts that may be taken to address these risks, as well as generate a new model to address crises/disasters of various types that might impact a construction project.

CHAPTER 2
LITERATURE REVIEW

Overview

Merriam Webster defines disaster as “a sudden calamitous event bringing great damage, loss, or destruction.” The definition for the closely related word “crisis” refers to “the unstable or crucial time or state of affairs in which a decisive change is impending; especially one with the distinct possibility of a highly undesirable outcome” (Merriam-Webster). It is for these two events; “crisis and disaster” that the research sciences are trying to create models of defense and recovery which can lead to a better outcome. Crisis could be the origin of disaster, and disaster could be the beginning of another crisis.

Disaster is perceived as “a state of extreme ruin and misfortune,” and it is worthy of being addressed critically. Disaster can also be viewed as “any incident that can focus negative attention” in a company and have an adverse effect on its overall financial condition, its relationships with its clients, or its reputation in the marketplace (Reid 2000).

It was not until the 1930s that the U.S. government became actively involved in crisis/disaster response and then did some informal work by providing funding to repair highways and bridges damaged by natural crises/disasters or building flood-control projects. Nuclear war and nuclear fallout were the greatest risks in the 1950s and most emergency management efforts were focused on civil defense programs at all federal levels. During the 1960s and 70s, a number of large natural crises/disasters beset the country, conspicuously the Ash Wednesday storm along the mid-Atlantic coast of the United States (1962), the Alaskan earthquake (1964), Hurricane Camille (1969), the San Fernando Valley earthquake (1971) and Christmas tsunami (2004). The Centre for Research on the Epidemiology of Disasters analyzed graphically the geographical distribution of natural crises/disasters at the world level from 1976 to 2005 (Figure 2-1). More than 120 natural crises/disasters were noted in such countries as Russia, China, India, Iran, Australia and the Unites States.

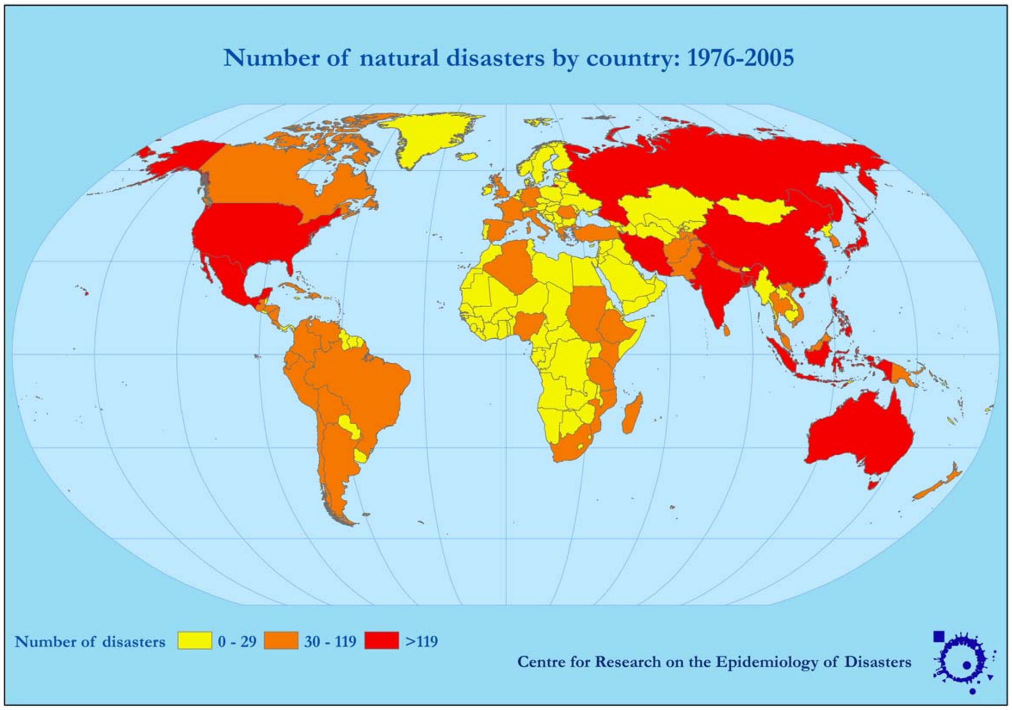

Figure 2-1 Number of natural disasters by country: 1976-2005 (Source: Natural Disasters Maps. EM-DAT Emergency Disasters Data Base)

Even after a series of critical events, federal assistance was continued to be extended only on an ad hoc basis where special needs arose. Many of the government agencies and departments had partial responsibility or limited governing authority over crisis/disaster response. In 1979 the Federal Emergency Management Agency (FEMA) was created in order to centralize emergency management functions at the federal level.

Preparedness is the foundation of emergency management and helps to reduce vulnerability to threats. The establishment of warning systems, evacuation plans, pre-impact preparedness, special-needs and similar responses should not be a mere “elegant traffic analysis” but carefully worked out practical plans. The most vulnerable population should be taken into consideration when making plans. Although it is difficult to predict the number of crises/disasters in the coming years, the time trend of natural crises/disasters from 1975-2005 shows an increase in the number of crises/disasters for the past years. Many of these crises/disasters occurred in high population countries such as the People's Republic of China and India. A significant number of crises/disasters also hit the United States (Table 2-1). As shown in Figure 2-2, the number of crises/disasters appears to be increasing.

Table 2-1 Top 10 Natural disaster by number of deaths: 2005 (Source: EM-DAT: The OFDA/CRED)

Top 10

Natural disasters by number of deaths - 2005

Earthquake, October	Pakistan	73 338
Hurricane Stan, October	Guatemala	1 513
Hurricane Katrina, August	United States	1 322
Earthquake, October	India	1 309
Flood, July	India	1 200
Earthquake, March	Indonesia	915
Flood, June	China, P Rep	771
Earthquake, February	Iran, Islam Rep	612
Measles Epidemic	Nigeria	561
Flood, February	Pakistan	520

Countries most hit by natural disasters - 2005

China P Rep	31
India	30
United States	16
Afghanistan	13
Bangladesh	12
Pakistan	11
Vietnam, Indonesia, Romania	10
Iran (Islam Rep), Russia	9
Haiti	8
Mexico, Turkey	7

Victims (killed and affected) of natural disasters per 100,000 inhabitants - 2005

Comoros	42 512
Malawi	37 376
Guyana	35 909
Niger	30 863
Cuba	22 914
Albania	11 240
Zambia	10 666
Djibouti	9 859
Kenya	7 497
Mozambique	7 461

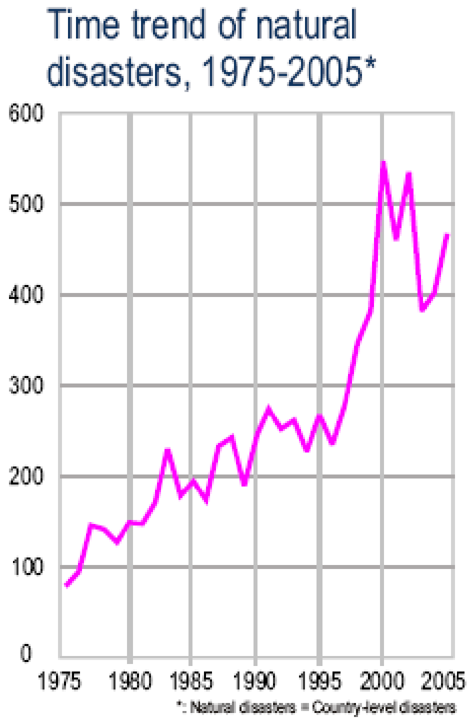

Figure 2-2: Time trend of natural disasters, 1975-2005 (Source: EM-DAT: The OFDA/CRED)

The number of people killed from 1991-2005 was examined by different categories of development level of the countries which is shown in Table 2.2 and Figure 2.3. Figure 2.3 projects the percentage of loss caused by major natural crises/disasters in different areas of world categorized under different levels of development.

Table 2-2: Number of people killed by type of crisis/disaster and level of development 1991-2005 (Source: ISDR. Disaster Statistics)

	Flood	Wind storm	Drought*	Slide	Earthquake & tsunami	Volcanic eruption	Epidemic	Total
OECD	2150	5430	47516	426	5910	44	442	61918
CEE+CIS	2635	512	3109	1176	2412	0	568	10412
Developing countries	97061	65258	12599	9369	397303	900	47616	630106
Least developed countries	20127	149517	3320	1739	9247	201	70588	254739
Countries not classified	99	767	57	23	2277	0	104	3327
Total	122072	221484	66601	12733	417149	1145	119318	960502

*: Drought related disasters category includes extreme temperatures

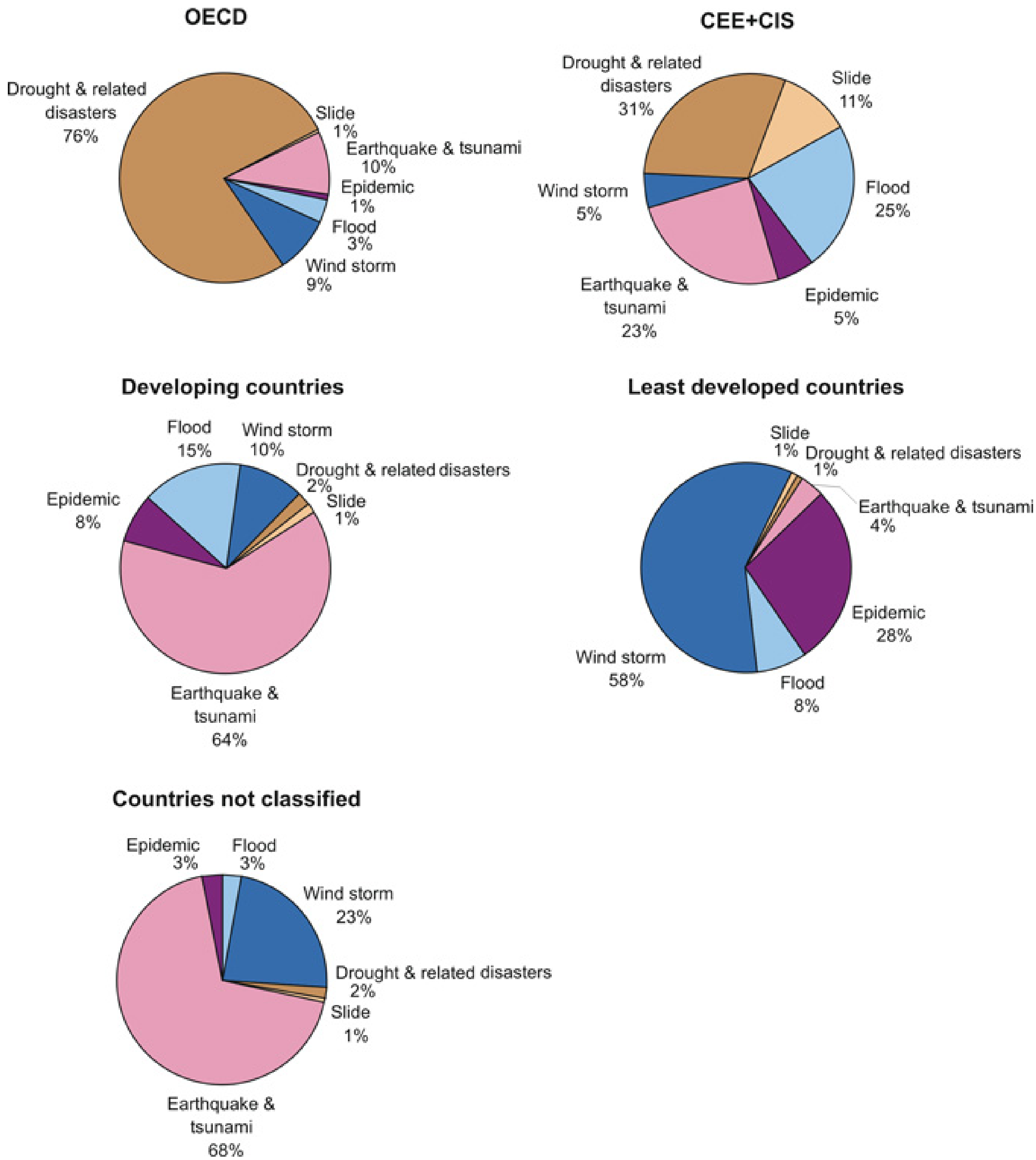

Figure 2-3: Number of people reported killed by type of crisis/disaster and level of country development 1991-2005 (Source: ISDR. Disaster Statistics)

To plan for crisis/disaster, it is important to identify the various risks and to understand their inter-relationships. Losses from crises/disasters can take many forms on a construction project, including financial losses, physical destruction, and delays in the schedule (Cooper and

Chapman 1987). When addressing crises/disasters, it is important to anticipate failure modes and to then take steps to prevent those failure modes from developing catastrophic events (Petroski 1994). Catastrophic events are associated with high risk occurrences, but low risk occurrences with lesser impacts are also a concern. Low risk events tend to be handled by “redundancy” and “duplication” (Sagan 1993).

The US aircraft carrier operations are high risk in nature, especially during war time. These high risk operations involve computers, antennas and personnel. Because of the complexity, redundancy with additional assigned personnel and an overlap of responsibilities is standard procedure. In 2006, Michael Tarrant stated the following about risk:

> A key theme which is often raised is that there should be increased community participation and responsibility in managing risk. If there is an expectation of significant changes in behavior by individuals then risk assessment and/or risk management will have to move beyond the idea that risk is something that is independent of minds and cultures, waiting to be measured. Unless an approach is developed that moves beyond technical assessments, people are doomed to be met with either apathy or occasional aggression by the public when attempting to engage them in managing risk. The idea that risk can be objectively quantified is often expressed in equations such as risk = consequence x probability.

Risk management consists of assessing, minimizing, and preventing accidental loss to a business, as through the use of insurance, safety measures, etc. Risk assessment on every project is a valuable exercise for any project management team to address. This may eventually be addressed in the general company policies on site management. Companies should focus on the kinds of plans required to address the needs created by crisis/disaster. Some have tried to increase the probability of successfully managing risk by teaming up with others. OSHA has worked with the National Response Team of the Environmental Protection Agency. Also, the Department of Transportation has made efforts to develop plans for addressing crises/disasters, but there is a lack of critical reviews being conducted. Salmon (2005) descried risk analysis at the world level, where terrorists' attacks were identified as the result of gap in the global architecture of governmental, non-governmental and quasi-governmental organizations

Hazard analysis involves identifying and assessing the characteristics of hazards in communities and the environment. If the trend to manage risk through greater participation and the acceptance of individual responsibilities is to be successful, then many issues will have to be addressed. Public education and awareness is of limited value until there is a greater appreciation of the way people think about risk and their decision-making processes. A key theme, which is often raised, is that there should be increased community participation and responsibility in managing risk (Tarrant 2006). Alexander (2006) described the globalization of crises/disasters with the vulnerability as the conditions determined by physical, social, economic, and environmental factors.

The National Response Plan establishes a comprehensive all-hazards approach to enhance the ability of the United States to manage domestic incidents. The plan incorporates best practices and procedures from incident management disciplines (Federal Emergency Management Agency or FEMA, National Disaster Medical System or NDMS, Urban Search and Rescue or USAR, Disaster Mortuary Operations Response Team or DMORT, Disaster Medical Assistance Team or DMAT etc.), and integrates them with the entities:

- Homeland security
- Emergency management
- Law enforcement
- Firefighting
- Public works
- Public health
- Responder and recovery worker health and safety
- Emergency medical services
- Private sector

Smith (2006) refers to the use of special code systems in the alert mechanisms for hospital emergencies. The examples of the codes include the following:

- **Code blue:** Medical emergency
- **Code red:** Fire
- **Code white:** Pediatric medical emergency
- **Code amber:** Infant or child abduction
- **Code yellow:** Bomb threat
- **Code gray:** Security emergency/ patient elopement
- **Code silver:** Hostage situation
- **Code orange:** Hazardous material
- **Code triage:** External disasters situation
- **Code clear or green:** Situation is resolved

It has been suggested that a similar code designation needs to be developed for the construction industry. Much effort is needed to integrate practices and procedures into a unified structure. Big companies have more resources than the small firms. Big companies can have multiple construction sites that can be utilized to provide resources to a construction site that was struck by crisis/disaster. Small businesses have a few options so they need to be more creative when drafting their emergency plans (Barrel 2007). Because of the limited resources of the small firms, federal departments and agencies will work together with them to coordinate with state, local, and tribal governments and the private sector during crisis/disaster incidents. Established protocols are necessary to help protect the nation from terrorist attacks and other natural and man-made hazards; save lives; protect public health, safety, property, and the environment; and reduce adverse psychological consequences and disruptions to the American way of life.

Roger Kemp (2007) presents a nine point formula to assess the vulnerability of buildings to crisis/disaster:

1. Visibility
2. Criticality to Jurisdiction
3. Site Impact outside the Jurisdiction
4. Public Accessibility
5. Possible on-site hazards

6. Building Height
7. Building Construction sturdiness
8. Site population capacity
9. Potential for Collateral mass casualties

Kemp states that the office, storage and manufacturing plants are not the targets of the terrorist’s attacks, but the governmental buildings, transportation centers, nuclear plants, and factories that produce war materials. It is almost unpredictable to know the minds of terrorists but Kemp encourages more preparation in the above mentioned facilities. The scale of the construction project is the most important factor which Kemp forgets to mention. All the weaknesses in the security systems are the causal factors in the crises/disasters by terrorism.

In 2000, Gunes and Kovel, described the use of Geographical Information Systems (GIS) in dealing with the hazards for Douglas County in the state of Kansas. The GIS-based decision support system was developed to safeguard against the flood zones in Douglas County. The flood zones were made to be identified and analyzed accurately using GIS technology. Orthophoto, hydrography, and digital elevation models were used to obtain a total understanding of the area under study. The study encouraged the use of graphical image systems as even a non-technical observer could analyze the area under consideration. In addition, other supportive methods of understanding the geology and soil zones using graphical systems can be helpful for addressing crises/disasters in the construction industry. Employing special emergency consultants is described by Brown (2002), as one of the solutions where consultants can provide the construction companies with written emergency plans and can visit the facility maintaining its safe completion.

Leonard and Howitt (2006) wrote about Hurricane Katrina as the most devastating storm. They made comparisons with Hurricane Andrew in 1992 and the Missouri River floods of 1993. The damage caused by Katrina occurred over nearly 100,000 square miles of area, roughly the land mass of the United Kingdom. The aftermath had the people stunned, as instantaneous response was difficult to analyze and put into action. The lesson learned was that the United States was not prepared for such a big crisis/disaster. Many construction sites were ill-prepared to address such a massive attack by nature.

In 2006, the Oklahoma Sciences Research Center prepared a six-step model to improve the capacity of public health agencies to respond to any hazardous event. The proposed model integrated aspects of two existing approaches with concepts from the field of emergency management, and emphasized the importance of timely evaluation. The evaluation of this paradigm included both individual workers and larger work groups. It addressed both general goals and the agency's local plan. This model also stressed the need to work with all levels of the agency to develop the local plan. The evaluation was accomplished using self-assessment, measures of objective knowledge, ratings of individual performance, and ratings of team performance. Though based on a pilot study, that model may have applications for other agencies working to increase their capacity to respond to hazardous events.

Terms

The research by International Strategy for Disaster Reduction (2005), focused on different environments of construction, so the understanding of a few terms could be helpful in creating solutions for the emergency events. The terms are as follows:

All-hazards approach: an integrated hazard management strategy that incorporates planning for and consideration of all potential natural and man-made hazard threats, including terrorism.

Disaster risk: the chance of a hazard event occurring and resulting in disaster

Hazard event: the specific occurrence of a hazard

Hazard risk: the chance of a hazard event occurring

Natural disaster: a disaster that results from a natural hazard event

Natural hazard: a hazard that originates in natural phenomena (hurricane, earthquake, tornado, etc.)

Man-made hazard: a hazard that originates in accidental or intentional human activity (oil spill, chemical spill, building fires, terrorism, etc.)

Emergency planning: procedures and steps taken immediately after an interruption to construction activity

Disaster recovery: steps taken to restore some functions so that some level of services can be offered

Business continuity**:** restoration planning, completing the full circle to get the organization back to where it was before an interruption

There are no generalized templates, as one framework for crisis/disaster planning and recovery cannot fit all. There are some common elements among plans, but every charted plan will be unique because every organization's structure and circumstances are unique. It is the objective of this research to develop a generalized crisis/disaster management plan that could address a wide range of crises/disasters.

Construction Companies and Community Relationship during Crisis/Disaster Events

Americans in today's world are more vulnerable to hurricanes than in the past. The hurricane-prone coastline of the United States now houses nearly 50 million people. Hurricane Katrina devastated a major city in 2005. The commitment to reach the community in crisis/disaster event could have been best served if had a plan of action for them too. Unfortunately, there was no orchestrated plan; certainly none that could that could address a crisis/disaster of the scale of Hurricane Katrina.

Natural crises/disasters of the scale of Hurricane Katrina need crisis/disaster planning at the community level. Local construction firms can also play a significant role in the recovery phase. The community services that can be provided to the neighborhood after natural crises/disaster includes such activities as cutting down fallen trees; hauling off the debris; and providing transportation; supplying water and providing other needed services. The construction company could make a decision to defer actions on its own project site, while the community needs are addressed. A company could take complete control of the situation or work closely with the governmental agencies in addressing the issue. The National Guard could be served by contacting them directly. Assisting the community can help the company's own workers feel pride in the values of the organization's policies and humanitarian work.

Community services and the company's own construction project require attention and a decision is needed on how to best allocate the resources. This decision will be based on the nature of the damage inflicted by the crisis/disaster. Three different scenarios are possible at the time of crises/disasters, which are as follows:

- Crisis/disaster at construction site and community unaffected
- Crisis/disaster at construction site and community also affected
- Construction site unaffected, but community suffers from crisis/disaster

The organization could think of supporting the community with transportation vehicles or some other equipment to help the neighborhood address its immediate needs.

There are often special needs of the community or neighborhood in times of crisis/disaster. If only the construction site has sustained damage, all efforts will be focused on the construction site. If, both the construction site and the community are affected, allocating resources between the construction site and the community will be the key decisions to be made in the early stages. Providing assistance to the community in the hours of crisis may be a moral obligation assumed by the company. In the case where only the community is impacted, the immediate need will be to implement actions for the benefit of the community.

History is replete with examples where parties in neighboring area came out and helped those in the community in a time of need. For instance, after the Teton Dam collapse on June 5, 1976 (Figure 2-4) the construction companies in the region provided help to the community. Bulldozers and crews were immediately deployed to “plug the leak.” Some workers put themselves at risk to help the community. The construction companies extended their commitment beyond financial support. Donations of diverse supplies, equipment, services and expertise to enhance the on-ground relief activities saved lives and resources.

Figure 2-4: Oblique aerial view northeast and upstream of Teton Dam site as it looks today (Source: U. S. Bureau of Reclamation)

CHAPTER 3
METHODOLOGY

The overall objective of this research was to develop a model that could be used to address the effective management of any crisis or disaster that might impact a construction project. With the model, a construction manager could devise an appropriate management plan to address an impending or potential crisis/disaster. As such, the model could provide the underlying foundation to develop a management plan to address any crisis or disaster. The challenges for developing the model on crisis and disaster management were associated primarily with the varying types of calamities and their consequences. For example, the model was to address minor crisis situations (power failure) and major disasters (hurricanes).

The methodology followed in this research was guided by the objectives of the study, which were to develop a standardized approach for disaster mitigation and crisis management in construction.

The steps taken to obtain sufficient information on crisis/disaster management were as follows:

- A literature search was conducted on relevant material describing emergency management, disaster mitigation and any crisis event that might impact a construction project
- The impacts of crises/disasters and events were studied on a global basis
- The private and public institutional efforts of crisis/disaster management were collected
- Media coverage on crisis/disaster cases was studied
- Construction industry approaches to address crisis/disaster situations were examined in journals, magazines, the Internet and newspapers
- The data on relevant case studies were collected and evaluated

The research was aimed at creating a model or a collection of models for crisis/disaster management on construction projects. The use of generally accepted terms rather than technological terminology was considered essential for ease of use. In the process of developing a solution for this complex issue, the initial development steps were divided into three different categories

- Higher magnitude disasters
- Lower category disasters
- Localized disasters

The management of a crisis/disaster is highly dependent on the nature of the event. Varying levels of preparation will be required for different events. The impact of a crisis/disaster on the community and a construction site can be enormous. The model to be generated was to sequentially address all the parameters associated with the preparation for a crisis/disaster and the recovery period. The higher magnitude disasters were the most important of the listed crises/disasters as they could result in greater consequences. Higher magnitude “man-made disasters” are not common and are generally associated, in recent times, with acts of terrorism. The man-made crisis/disaster events were considered to be rare so that this research did not consider them. The higher magnitude types of crisis/ disasters include the following:

- Earthquake
- Extreme snow/ ice conditions
- Extended freeze
- Flood
- Drought
- Hurricane/tropical storm
- Lightning, especially associated with subsequent fire
- Tornado
- Tsunami
- Avalanche
- Landslide/mudslide
- Surface faulting
- Ground failure
- Disease epidemic

Lower order disasters can also adversely impact construction projects. Even though the elements of disaster may be small, their consequences could be disastrous, especially if a chain reaction is initiated. For example, a small fire caused by a lightening strike could result in an explosion and widespread damage. Also, in the structure of a building, the whole system could fail due to progressive collapse. Thus, one small event could result in a major disaster. The research identified several lower category crises/disasters including the following:

- Environmental accidents
- Groundwater contamination
- Long term exposure of a community to toxic chemicals
- Release of toxic chemicals into the air or water channels
- Disease epidemic (Terrorist Act as anthrax threat)

Localized crises/disasters are seen as a potential threat to the safe completion of construction projects. Even if the area of influence is not a whole city or town, it can still impact greatly on the company performing the operations. Human error is recognized as one of the most crucial causes behind localized disasters. For instance, major sources of hazardous material accidents are spills along roadways, railways, pipelines, rivers, and port areas. Hazardous materials are substances, which are harmful to the health and safety of people and to property.

Subcategories of localized crises/disasters include the following:

- Injury/ fatality of an employee
- Exposure to hazardous/radioactive material/oil
- Chronic safety problems
- Homicide
- Suicide
- Accident on the jobsite
- Violent acts
- Terrorism
- Damage to utility lines
- Equipment failure
- Theft/ embezzlement
- Damage to utility lines
- Fire

- Violent strikes
- Sabotage
- Power failure
- Suspicious material

There are also a number of cases, which are out of the scope of this study. The following categories were not considered in the model development.

- Operational misconduct/ management/ administration
- Discontented employees
- Fraud
- Bankruptcy
- Contractual disputes with a client
- Mergers/acquisitions
- Negative publicity relating to politics
- Grievances
- Labor issues and appeals
- Sudden market uplift
- Blackmail
- Harassment
- Human rights violations
- Reorganization/ downsizing
- Sudden governmental changes in policies
- Scandals
- Serious cash flow problems
- Rapid growth
- Lack of bonding capability
- Computer viruses

Institutions in different industries have their own working models of preparedness and response for crisis/disaster. For example, the health-care industry has response models to address multiple emergency room admissions resulting from a single catastrophic event. Response models were also noted in the area of sports where sports teams employ physicians to attend to unexpected serious injuries of players. Similarly, response models of police departments, fire departments, and national emergency services with other parallel organizations (Red Cross, International Strategy for Disaster Reduction Group) were examined in preparation for developing a crisis/disaster management model. These have served as inspirational models in the development of the construction crisis/disaster management model.

The research had a prime focus on developing a model that would help in “preventing” as much damage from crisis/disaster events as possible by generating a working model on which effective crisis/disaster management plans could be developed and implemented. Although the model is not designed to prevent the occurrence of a crisis/disaster, it is designed to dramatically reduce the adverse impacts of such events. The action plans for different types of crisis/disaster events were evaluated. For example, consideration was given to the appropriate responses to address major events as hurricanes and less serious events as power failures. By examining various major and minor events, a wide range of mitigation response actions were identified. After that, the responses to several different types of crisis/disaster events were analyzed and common elements were identified between the different approaches. Through this exercise, it was decided that a single model would be developed, i.e. most of the response elements were similar for very different crisis/disaster events. As the model was developed, it was tested to determine if it adequately addressed the needs of crisis/disaster management for different types of events. Through this process, iterative improvements were made to the model until it was deemed to be finalized. The final version was felt to adequately address the many types of crisis/disaster events that were examined.

Further validation of the model was conducted through a third party review. J. D. Lewis, Regional Safety Director of Bovis Lend Lease, reviewed the model for applicability to real world crisis/disaster events. Mr. Lewis suggested the formulation of a “Plan B” as an alternative in case the basic plan could not be used. It was decided that once a management plan has been developed for a crisis/disaster, an alternative plan would be appropriate in many instances. If such an alternative plan were to be developed for a particular crisis/disaster, the same crisis/disaster management model could still apply.

CHAPTER 4
RESULTS

The research developed a standardized model for crises/disasters that impact construction projects. The model was prepared to address virtually any kind of crisis/disaster situation that could arise on construction projects. The model known as the Construction Crisis/Disaster Management (CCDM) model, has primarily three subparts:

- Plan in place to address crises/disasters
- Actions to be taken to prepare for a forecasted event
- Response to and recovery after an event

The three subparts are associated with a series of different steps as shown in Figure 4-1. The "plan in place" consists of charting out procedures with constant refinement and revision. In the case of an advanced warning of a crisis/disaster, certain actions are activated for the response. Not every event will have an advanced warning, so "plan in place" can assist in reducing the impact of a crisis/disaster even when there is no adverse warning. "Response and recovery" constitutes all the actions taken during and after the crisis/disaster event. Every step in the CCDM model contains three parts which are: assigning responsibilities, documenting contact information and identifying respective action steps.

All levels of crisis/disaster management need the commitment of top management. Also, crisis/disaster management is a function handled by a team of individuals and is not the work of a single person in top management. Although, management involvement at various levels of the crisis/disaster model is crucial, individual participation with allotted responsibilities can successfully implement the model.

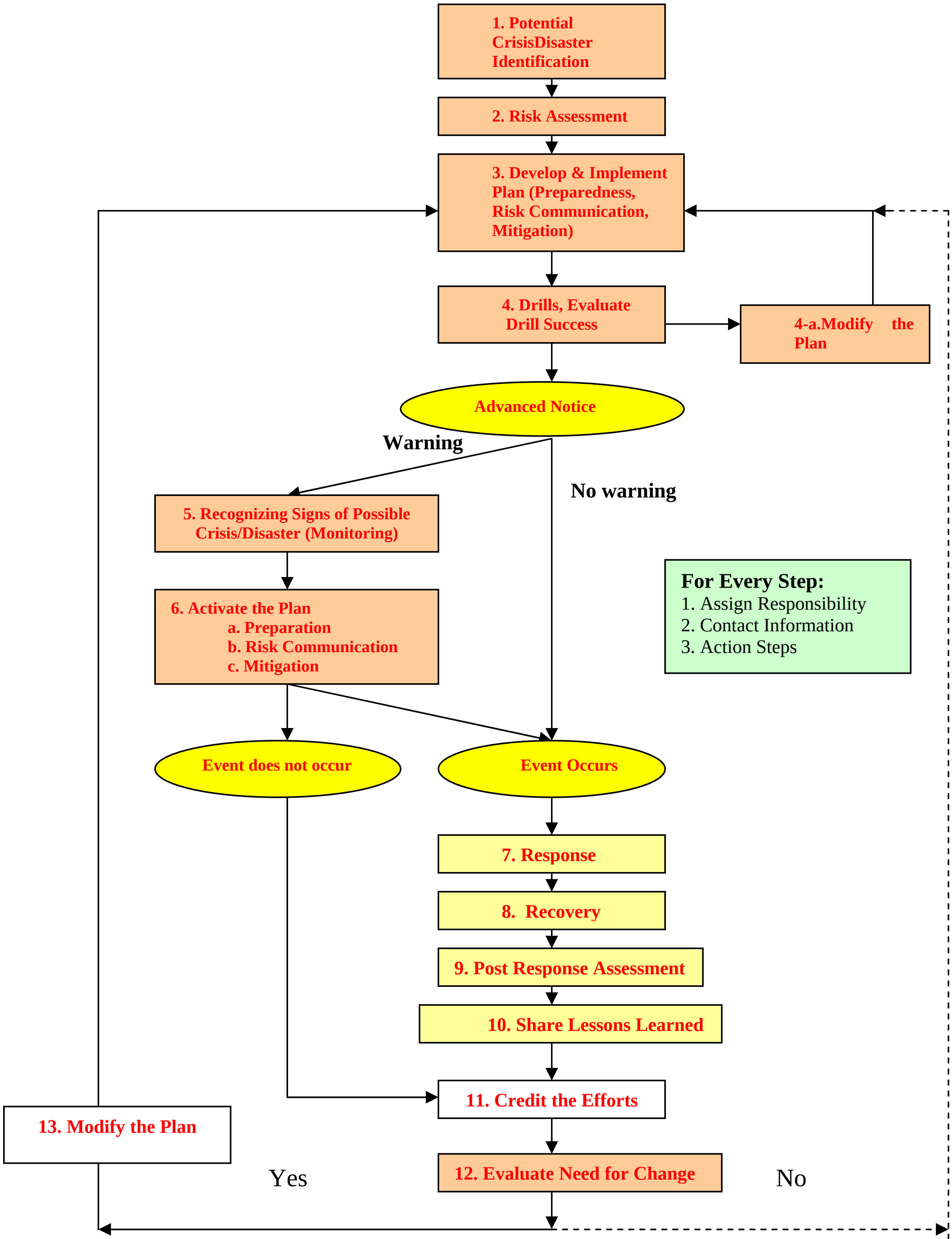

Figure 4-1. Model for construction crisis/disaster management (CCDM)

Description of Construction Crisis/Disaster Management (CCDM) Model

Crises/disasters which can be anticipated can be managed and they are the ones that can be attenuated or even avoided. The following is a step-by-step description of the CCDM model:

Step 1: Potential Crisis/Disaster Identification

Crisis/disaster identification is the first crucial step in the CCDM model. The key points in the identification process are:

- Identifying potential crisis/disaster that may impact a construction site
- Examine historical evidence on past natural crises/disasters in the area

Step 2: Risk Assessment

The risk assessment is conducted on a potential crisis/disaster to determine if a management plan is to be developed for it. If not, the management plan is not needed and it is not developed. Certain crises/disasters could develop in progressive stages of growth, whereas others might not show any warning signs. The initial identification of the probability of occurrence could result in efforts to stop the crisis/disaster and its aftermath. The risk for the identified crisis/disaster event could be studied with the help of the following steps:

- Studying the site topography, site plans and prevailing weather conditions
- Understanding the geological, meteorological, and in some cases epidemiological factors associated with specific crisis/disaster events
- Understanding the use of remote sensing technologies like geographical information systems (GIS)
- Studying the surface elevation models with orthophotos, hydrographic surveys in case of flood zones
- Understanding all existing infrastructure facilities in the construction site region
- Understanding and training of medical procedures such as first aid
- Analyzing the budget for emergency services

- Hypothesizing the probable agents of crisis/disaster based on regional geography, history, and past construction accidents

The formula for risk is, risk = probability of occurrence X severity of consequences. The risk calculations take into account a number of factors and inferences on the site-specific conditions. The manager's intuitive capacity and foresight about crisis/disaster events could help in these risk calculations. For example, the probability of a nuclear strike on a construction site at Gainesville, Fl is nearly zero percent, hence the risk associated with such an event is nil.

It can be assumed that the tornado that hit central Florida in February 2007 was an indicator of a weather crisis/disaster that could occur again. There, the risk associated with a similar hit by such an event has an increased probability. In risk calculations, factors of probability, consequences, phases of construction project, and kinds of the construction activities occurring at the time could be helpful in conducting an overall risk analysis.

Consider an example of a construction scene in New York City. The city is located in the Northeast region of United States where the climate is primarily humid and all storm frontal systems move eastward across the continent. The probability of being hit by a well-developed storm system is high during winter. These storms generally continue to move eastward or along the Atlantic coast accompanied by very strong winds, causing considerable property damage over wide areas of the state. Other severe weather conditions could include high rainfall, thundershowers, windstorms, snowstorms, blizzards, extreme heat, and drought, all of which might inflict damage on a construction site. The season of the year associated with hazardous weather conditions, along with the phase of construction of a given project, should be analyzed to objectively measure "risk" for the construction projects in New York. The consequences of a storm could be predicted from the analysis of photographs of past disasters, buildings devastated by similar weather patterns and rehabilitation provided by the governmental and non-profit organizations.

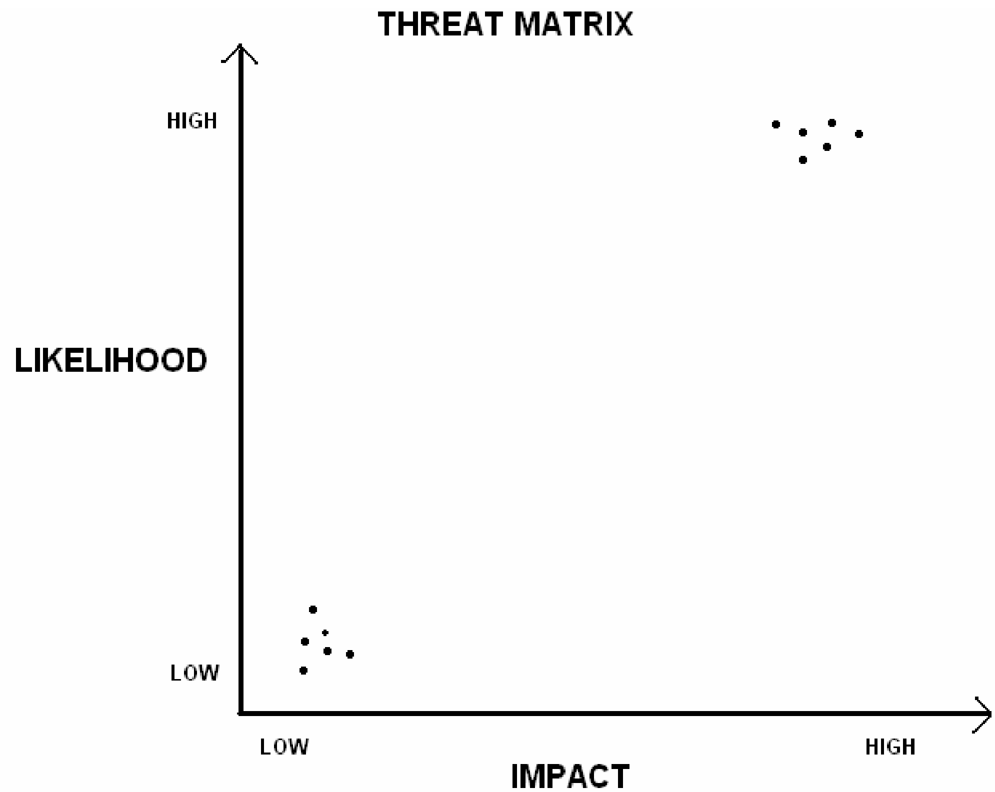

Figure 4-2: Risk Analysis of the construction crisis/disaster at various levels

The risk analysis of the probability of occurrence is the “likelihood” that an event will take place and the consequences of the occurrence can be referred as the “impact” that the event will have. If the project is under a lower probability of occurrence of the crisis/disaster event and its consequences are also low, then it will lie under the lower left corner of the graph (Figure 4-2). For example, a project in the state of Florida is nearly under a zero probability of occurrence of hurricanes from January through March. If the consequences or impacts are also low, then the project is said to be in the lower threat zone of the matrix shown in Figure 4-2. In another case, a project under construction in the state of Florida during the month of August is under high probability of occurrence of hurricanes and the consequences of hurricanes on the projects is high, Under these conditions, the project is in the high threat zone of the threat matrix. Similarly, the risk analysis can be conducted for projects under different conditions with the "threat matrix."

Three-dimensional models, similar to architectural-presentation models, could be used to introduce on-table discussions and conduct further analysis. Introduction of various kinds of constraints, even during the construction phase, that can result in temporary or permanent damage to the facility could help in the risk assessment. In case of hurricanes, the structural design engineers must work closely with the construction managers to analyze structures and the potential impact of a crisis/disaster. It is required that the risk management must acknowledge the sequence of construction activities and their risks. The multiple crisis/disaster prone construction environments need careful risk evaluations.

Step 3: Develop and Implement Plan.

Directions and guidelines are created in the plan for all the ongoing construction activities on the site. It is important to develop a plan and then, train all the field workers and supervisory personnel to effectively act against the impending crisis/disaster. The plan can be divided into three different categories:

Step 3a: Plan for the pre-event phase: The following steps need to be taken.

- Prepare contact information
- Assign responsibilities to different site personnel
- Set up command centers (offices) with effective communication networks.
- Develop set rules and standard operating procedures so as to counter the agent of hazard in construction projects.
- Establish a central meeting place (or places) for all the employees.
- Assemble beforehand the emergency supplies that might be needed including, first aid kits, flashlights, radios, batteries, communication devices, food and protective clothing should be ready.

- Devise area sketches, map layouts, or any other kind of planning documentation associated with any probable crisis/disaster in advance.
- Set up communication networks, emergency team identification, command offices, and signal mediums in advance.
- Prepare all mitigation and risk communication services

Step 3b: Plan during the event phase.

The plan during the event will vary considerably, depending on the type of crisis/disaster. The action could consist of all personnel finding a safe place until the event passes. In other events, key activities can be initiated for a post-event response. In some cases the event itself is so short that virtually no activities can actually be planned, e.g., lightning strike. Responses to the event should be well coordinated between all the site personnel.

Step 3c: Plan for the post-event phase.

Plan for the post-event phase comprises of all the activities which help in restoring the project to regular construction operations. Management may consider utilizing the help of experts for the analysis of damage and recovery procedures. All the site personnel should not start any activities until asked to do so. The aftermath of the event can be devastating in certain cases (hurricanes, tornadoes, fires, etc.), where complete rebuilding of the site from the initial stages is required. Also, in other cases (low intensity earthquake), the effects might not be harmful, like certain small cracks in the structure might reveal only superficial damage. The collection of saved materials and resources is also one of important steps in the post-event phase.

Certain crisis/disaster events might be avoided if proper preventative measures are implemented on time, e.g., the use of alternative uninterrupted power supply in case there is a power failure. Also, proper lighting could save the construction site from an act of arson. The planning stage establishes all the activities to be followed during the developing stage of a crisis/disaster. All designers, engineers, planners and managers should work together to mitigate the attack of probable crisis/disaster events on the construction projects.

Step 4: Drills & Evaluation of Drills:

Drills consist of exercises conducted which can test the full strengths and weaknesses of the management plan. In the process of conducting a drill, regular construction activities stop and a simultaneous response to a crisis/disaster is conducted. Human shelter and all other arrangements (depending on the crisis/disaster) for the crucial hours need to be well coordinated with all site personnel. Restarting the interrupted activities and returning to regular work tasks are the aims of a drill. The specific tasks performed during the drill will depend on the specific crisis/disaster that is being simulated. It is a test of actions which can combat the simulated crisis/disaster using equipment, materials and procedures.

In case of suspicious substances on the site, the following steps constitute the drills:

- On-site management to be notified immediately
- Communication to warn all site personnel
- Promptly shut down all operations in defined piece of time
- Evacuation of all site personnel
- All the evacuation routes serve all the traffic flow, so all routes and fire doors should be working
- All the emergency alarms and lighting should be installed and should be working properly
- All the site personnel should assemble at a common meeting place
- Alternative shelter should be available in good condition
- Remove the suspicious substance from the working zone to avoid exposure
- Avoid contact with any exposed personnel

- Sheriff’s and emergency responders to be called and only they are allowed to handle the substance
- If the substance lies inside the covered site, then ventilation systems must be assessed to determine if they are to be shut down

If the substance lies outdoors, all flammable substances and ignition sources are to be removed

Evaluation of drills for the adequacy of planning for the crisis/disaster event is done after every exercise. The success of the drill prepares the site personnel mentally for an actual event to be addressed more efficiently. Any mistake in the drill teaches lessons that should not be repeated. If there is a need of the plan to be modified due to its weaknesses, then new elements should be introduced in the revised plan. Continuous modifications, drills, and continuous planning create a stronger solution for the crisis/disaster management plan.

All the steps of the CCDM model establish the need of constant feedback of ideas in the development of plans. An alternate plan could be activated if management realizes that the initial plan is unsuitable. The alternative plan needs to be evaluated in a similar manner to the initial plan with rigorous drills.

Advanced Notice of the Crisis/Disaster

Crises/disasters can vary considerably in terms of the extent of advanced notice or warning signs that are given about the eventual occurrence. When an advanced warning exists, it is important to watch for the signs and to recognize them. Additional steps can be taken in the crisis/disaster plan to reduce the impact of the crisis/disaster as preparations can be made.

The advanced warning is the forecast or likelihood of the occurrence of a particular event. The monitoring or observation of the event and immediate preparation can save the company from the crisis/disaster’s after-effects. The advanced awareness of the coming event could help in identifying and understanding the following:

- Potential consequences

- Level of risk and probability of occurrence

Observation may be the most important factor in saving a construction project from a crisis/disaster. The failure to recognize the signs of a crisis/disaster in the early stages could result in conditions whereby all construction activities would stop once the crisis/disaster became a reality. The crisis/disaster conditions could be studied with the following characteristics:

- Strength: the magnitude of the crisis/disaster will dictate the ease of recognition
- Occurrence: the likelihood of occurrence will define the level of risks
- Action period: the striking phase or duration of the impact of a crisis/disaster event must be carefully studied
- Coverage: the area under influence or the extent of impact
- Velocity: the speed and direction of the crisis/disaster
- Pattern recognition: the trends and all composite elements of the crisis/disaster

For natural crises/disasters, the weather agencies can predict such events as thunderstorms, rain, hurricanes, and snow-storms. Some crises/disasters, such as fires from lightening; tornadoes, and earthquakes cannot be predicted with accuracy. Different methods are utilized to help forecast different events. In case of an accident on the jobsite, nothing could be predicted as accidents just happen without notice, although there are indicators of poorer safety behavior that might suggest a higher probability of occurrence. For example, the behavior of a worker might be a precursor to an accident, as in case of a worker under the influence of a controlled substance.

A winter storm watch by the weather agency means that conditions are developing in the area under study for a winter storm and usually these can be predicted 12 to 36 hours prior to occurrence. A blizzard warning means that strong winds, blinding wind-driven snow and dangerous wind chill are expected and preparedness for proper shelter is indeed required within hours.

Step 5: Recognizing Signs of Possible Crisis/Disaster (Monitoring)

Weather services inform the public through media of approaching crisis/disaster events. Weather warning can be valuable for management personnel on construction site. Once it is apparent that a predicted event will impact a construction site the crisis/disaster plan is activated.

Step 6: Activate the Preparation and Mitigation Plan

The activation of the plan needs the site personnel to act efficiently on the charted out plan. Care should be taken on the timely activation of the plan. Actions are taken to

- Prevent or reduce damage
- Provide protection during the event
- Be ready for the post event response

The activation step is further divided into three categories: preparation, risk communication and mitigation. The subcategories are explained as follows:

Step 6a: Preparation

The advanced notice to an upcoming crisis/disaster event gives time to prepare and respond effectively. The developed and tested plans are activated at this stage. The preparation may include the following steps:

- The plan of action is finalized, in case additional modifications were deemed necessary
- The life safety plans and all emergency routes should be ready to be used
- Documenting, analyzing, and protecting the utility shutoffs, electrical cutoffs, electrical substations, storm drains, sewer lines, MEP lines, gas lines, fire suppression systems, restricted areas and valued-items
- Identifying the resources needed to address the consequences of the crisis/disaster event
- Ensure that assigned responsibilities are assumed by the designated individuals.
- Understanding the timing and sequence of different activities

- Identifying all the personnel resources that will be utilized: location, phone numbers, hotlines, operations manual

- Consideration of viability of the alternative plan for the assumed crisis/disaster

- Saving all the potential intellectual properties, computer files, data servers placed under different divisions and multiple regions, use of Application Service Providers (ASP) as databases over the Internet. The use of easily portable ipod option could be used to save records for the company

- Setting up of alternative power resources such as uninterrupted power supply (UPS) systems

- Collecting all necessary inventory items: first aid supplies, material supplies, equipment, vehicles

- Networking: both private and public connections intact

- Understanding escape routes with GIS enhanced planning: spatial analysis, routes, transportation networks, connecting arteries, utility grids, vehicular haulage, evacuation networks, crowd control tactics and traffic control points

- Assigning shelters according to preference, capacity, needs, access, time-suitability and safety

- Assigning the alternative offices and worksites: The assigning of alternative locations for the continuation of business in the event all current working zones gets collapsed

- Constituting all the emergency shelters, evacuation plans, stockpiling measures, inventory control, maintenance of supplies and equipment, back-up life-saving services (e.g. power, water, sewage)

- Preparing the inventory of transportation services

The training of the construction management team working for the crisis/disaster management is crucial in the preparation phase. The training of the site personnel can consider the following:

- Mode of training could be classroom training and self study or independent study

- Special classrooms or worksite should be used to train

- Hardcopy, pamphlets, internet publications of training manuals should be used to provide the medium of training

- Bi/multi lingual use in the training documents and procedures should be beneficial in case the site personnel are from multilingual backgrounds and are less adaptive to single language

- Interactive software/DVD, Safety posters, pocket stuff should be used for reference

Step 6b: Risk communication

The communication is divided into two categories:

- Internal Communication
- External Communication

Internal communication is referred to the information flow inside the company and external communication is referred to the information flow to the external agencies for help and coordination. The communication of construction crisis/disaster plan consists of collecting, processing, and disseminating of all relevant information by all probable means.

The information dissemination is to occur in a stipulated time frame. As soon as management becomes aware of the potential crisis/disaster, immediate actions should be taken, as a single second saved might be a value added to the plan. The internal communications should occur directly between the main office and to the designated responsible site individuals. It is important that the external communication to the life safety agencies (fire department, first aid services, police department, sheriff's office, any other governmental or private agencies and 911 centers) be made in a timely fashion.

Choosing contacts that are at different locations could be useful in letting management know the status. The company or on site authority may call or e-mail to check on each other in case of need during crisis. It is important that every managerial staff member on site has all the important contacts, and each other's e-mail addresses and telephone numbers (home, work, pager and cell). If phone calls become jammed due to heavy volume, then email should be used instead.

Satellite phones, which could be expensive, are one of the best options for the needed communication in a crisis/disaster. One could expect the most consistent mediums and communication networks to convey the signals in an instant. The interoperability of the communication systems can save considerable time in the circulation of news among the company members, so everyone should be using the same communication network provider.

Public warning systems provide assistance in the case of natural crises/disasters and even an alarm or radio in the crucial hours could be useful to communicate the crisis/disaster. The "get alert" signal from the radio or television may constitute communicating a natural crisis/disaster such as a hurricane or snowstorm. If time permits, the use of brochures, papers, phones and posters could also be viable means of communication.

Step 6c: Mitigation

Mitigation constitutes the exercises which can minimize the adverse effects of the crisis/disaster event. The company can save the construction site from a number of losses with the mitigation process. Here the risks related to construction projects could be projected to undergo attenuation, which could be termed as "risk-reduction." Some of the mitigation tasks that could be performed by the construction company are:

- Reinforcement of structural elements that might be in jeopardy
- Shielding the surfaces of walls
- Demolition of a structure, in case bracing or shield could be not be provided
- Mobilization of components, to a safer environment
- Evacuation of facilities and components
- Changing of the sequence of activities in the schedule of construction process if required

In certain cases, mitigation might not be possible, so evacuation might be the only viable option. Supply Chain Management (SCM) in construction requires being a master in knowing "what" they have and "where" it is. A model of SCM could be utilized to help the company better mitigate the effects of crisis/disaster by relocating materials and equipment to safer places of confinement.

Step 7: Response

The human reply to natural crises/disasters during the event constitutes the “response” phase of the CCDM model. Careful actions should be taken which can save lives and project resources from the crisis/disaster events.” Direction, coordination and not loosing the focus” are the most important elements in this step of CCDM model. The evacuation activity composed of evacuating people immediately from the danger zone is the most appropriate response activity in some cases. Controlling the intrusion of untrained and unsolicited visitors is important for their own safety. In case of fire on a construction site the immediate response would be extinguishing the fire. Of course, an assessment must still be made before acting. The fate of the recovery phase depends upon the effectiveness of the response action.

Step 8: Recovery

The restoration activity is aimed at restoring the working state of the construction site to operational status. The “recovery” state emphasizes the careful handling of all the damaged materials and protecting the reusable elements for construction. Recovery could be divided into two categories:

- On-Site
- Community

On-site recovery deals with site specific redressing activities, whereas the community level recovery activities are aimed at helping the community regain its normal status. Before any recovery efforts take place, an assessment must be made of the damage on the site. Serious hazards must be identified, e.g. powerlines knocked down, unstable structures, etc. Recovery at the construction site may be addressed by restoring powerlines, removing debris, recreating facilities, draining floodwater, cleaning up activities, restoring destroyed property, etc. Further recovery activities may include the following:

- Search and rescue operations
- Restoration and repair of roads
- Movement to high ground in case of flooding
- Distribution of food, clothing, shelter, health and medicinal articles (first aid kits)
- Salvage of materials
- Neutralization of the situation

The media can play a significant role in influencing the reputation of a contractor with the clients and the community. For example, a community might be impacted by a storm. If a contractor in the neighborhood quickly mobilizes to assist in the recovery and rebuilding phase after a storm, the goodwill of the contractor might be considerably enhanced. The media can help to highlight the beneficial actions of the contractor. Several articles in journals and newspapers were examined to understand how contractors had responded to past crisis/disaster events. The recovery phase is often seen with the intrusion of media personnel on the site. Media personnel and journalists aim at achieving the inside story of the crisis/disaster on the site. To safeguard the public image of the construction company, the following points could be used:

- Choose one spokesperson to handle the media and journalists
- Remain calm about the situation
- Ask the media to permit time to talk later
- Provide only pleasant responses, as the spokesperson can help preserve the company reputation by avoiding negative messages
- In any case, the spokesperson should not generate public outcry and should not be the source of any negative media coverage
- Demonstrate total control over the situation

The shocked and distressed people should be helped in the comforting process in this recovery phase. The family members of the one’s involved in the rescue operations or the ones offering assistance should be informed with compassion to create a less stressful environment. All arrangements should be made to restore the construction site to operational status as soon as possible.

Step 9: Post Response Assessment

The aftermath of the crisis/disaster and in some cases, their probable causes of occurrence are studied in this step. The post response assessment consists of the following:

- Documentation of damage on the effected site
- Expert analysis concerning the state of affairs
- Damage assessment
- Injury assessment
- Evaluation of monetary losses and saved articles
- Evaluation of the response and recovery efforts

Step 10: Share Lessons Learned

Learning is often the result of unfortunate experiences. This is also true of crisis/disaster events. After a company has responded to the occurrence of a crisis/disaster, it is advisable to examine the events that led up to the crisis/disaster and identify changes that might be taken to reduce any future losses.

The lessons learned in the post response assessment phase are shared among the team members to see what was missing in the preparation phase. The evaluations in terms of lost work hours, and even monetary-units and performance-units could be shared with the management team, so as to start a new plan of action. When causal factors can be controlled, additional efforts can be taken to prevent future crisis/disaster events.

Step 11: Credit the Efforts

The acknowledgement of the efforts of all the team members should be done shortly after the event has subsided. The continuation of operations involves strengthening the morale of those involved in the response and rescue operations. “Credit the efforts” could be summed up with the following points:

- Recognize the valor and success of saviors
- Console those adversely affected

Step 12: Evaluate Need for Change

The analysis of the mistakes and shortcomings of the preparations for the crisis/disaster should be made by the team committee. The objective of this assessment is to identify the need for specific changes. Reassessment of the plan from all perspectives is required to be made at various levels, from field supervisors to top management. The requirements for the response and rescue operations should be reevaluated at this time. The management team needs to address factors that could possibly contribute to the causation of crisis/disaster events. For example, structural failure could be studied as a consequence of improper design or contractor’s mistake of using incorrect construction techniques. If all went well in the planning and response phase, then there is little need to develop any changes in the plan. A decision needs to be made concerning the need for any plan modification.

Step 13: Modify the Plan

If the plan needs to be modified, then all appropriate arrangements for the strengthening of the model are to be made. Making modifications is a serious planning issue, where the help of certified engineers, designers, safety managers and others could make the next probable crisis/disaster less destructive. Since natural crisis/disaster may be unavoidable, the only remedy for them is to prepare a stronger defense system, thus planning more effective response measures. After the modifications are made, the revised plan can then be implemented, including the training, drills, and subsequent evaluations.

Discussion

Different events, constraints and conditions can be introduced to the applicability of the model. Ideally, the model should address any type of crisis/disaster event. Realistic construction scenarios will be used to test or examine the applicability of the model. Construction projects have numerous potential crises/disasters that could have a negative impact. Each of these potential crises/disasters requires a unique plan to mitigate the potential damage or harm that might result. While many different events might impact a construction project, three cases are presented to illustrate the application of the CCDM model.

Case of Hurricane

Step 1: Potential crisis/disaster identification: Hurricanes are most common in the coastal regions of the USA. In Florida, hurricanes might be potential crisis/disaster events from June to November. Further, certain regions of Florida which are near the coast are more susceptible to more damaging winds of hurricanes than the inland regions. Regional history of any area could be studied to identify hurricanes as potential crisis/disaster events.

Step 2: Risk assessment: In the aftermath of Hurricane Katrina, it became known that the risks associated with hurricanes could be extremely high. For a construction project in the path of a hurricane, assessments must be made about the potential for loss. This will depend to a considerable extend on the type of project and the phase of construction. As the hurricane advances towards a construction project, more details will become known about the potential risks. It is common to describe the hurricane by strength, designated as categories, which are 1, 2, 3, 4, and 5. These categories convey information about the wind speed and the expected storm surge (Table 4-1)

Table 4-1. Category of Hurricanes

Category	Wind	Storm Surge
1	74-95 mph	4-5 ft.
2	96-110 mph	6-8 ft.
3	111-130 mph	9-12 ft.
4	131-155 mph	12-18 ft.
5	156 +	18 + ft.

Since the strength of a hurricane cannot be predicted months in advance, (when a project is in the planning stages) the management plan must be developed for the worst case scenario. The on-site actions in response to an approaching hurricane will be tempered by the anticipated strength of the hurricane.

Step 3: Develop and implement plan: The preparations for the hurricane should start with top management. The plan could be divided into three different categories,

Step 3a: Plans for the pre-event phase: In the pre-event phase, the plan will be focused largely on reducing or minimizing the impact of the hurricane. The plan will address the following requirements:

- Inform all site personnel about the hurricane
- Form a response team with designated responsibilities
- Prepare for immediate closing down of operations and secure material and equipment on the project
- The emergency supplies including flashlights, first-aid kit, emergency food, water, dust masks, and battery operated radios should be available and in working condition.
- The development of mobile communication centers might be beneficial.
- The lines of communication must be outlined for the external and internal organizational charts. The external organization chart corresponds to all the external agencies to be contacted and the internal organization chart refers to all the contact information of all key company contacts. The location, telephone numbers, email-addresses, and fax numbers must be distributed among the designated team members. It is important that the transition of responsibility along the chain of command is without breaks.
- All the materials and valuable resources should be stored in secured areas.

- Information about local facilities such as medical centers, hospitals, nursing homes, schools, governmental offices should be distributed to all personnel.
- All site personnel are responsible for the security on site. Control over entry-exit gates and internal movement routes should be clearly established.
- The procedures to turn off the utilities should be taught to the key site personnel
- Emergency shut-off valves and emergency equipment should be ready for use.
- Insurance and contractual documents for post event response should be prepared.
- Ensure that there are adequate supplies of water and food on site in the event that the infrastructure fails completely.
- Wallet size laminated emergency cards with emergency action plan could be made and distributed to all construction team members.

Step 3b: Plans during the event: Hurricanes can produce violent winds, incredible waves, torrential rains and floods. The evacuation activities should have been done in the pre-event phase. This phase needs all the site personnel to stay indoors in safe shelter. While inside, all site personnel should remain away from outer doors and windows. The electricity should be turned off. All the construction activities should be stopped, until all clear is announced. Flying debris could hit any site personnel, so all should remain inside.

Step 3c: Plans for the post-event phase: The site personnel should watch for weakened structures and bridges, broken tree limbs or structures on the construction site that could collapse unexpectedly. Expert analysis of existing structures and the overall construction site should be made before starting further construction activities. In certain cases, the structure might need to be built again from start, whereas in other cases, small repair work can quickly restore the structure. Site personnel should not touch fallen or low hanging wires, or objects in contact with power lines. All efforts should be made to return the project to its normal construction status.

Step 4: Drills & evaluation of drills: Drills can be conducted to determine how well the plan has been organized and how well everyone understands it. A drill is essentially a simulated event. The construction site team is expected to demonstrate the evacuation and closing down activities in a minimal amount of time. The fire extinguishers should be working and everyone should know how to effectively operate them. Establishing an effective communication network will be of particular importance in the drill. Smoke detectors and signaling devices should be working properly.

The evaluation of the drill is essential. A critical review may identify shortcomings to the procedures. Then, modifications can be made to the plan. If substantial changes are made, a subsequent drill might be conducted.

Advanced notice: The National Weather Service or similar organizations can make meteorological predictions which can identify coverage areas, wind speeds and other characteristics of hurricanes. The coastal areas expected to be impacted with high water levels and high waves can be identified easily with accuracy.

Step 5: Recognizing signs of possible crisis/disaster: Hurricanes rotate in a counterclockwise direction around an "eye." A tropical storm becomes a hurricane when winds reach 74 mph. It is often feasible to know about the possibility of a hurricane 7 days to 24 hours before they strike an area, which can provide sufficient time for at least some preparations. A hurricane forecast involves the prediction of several interrelated characteristics, but the fundamental element of the forecast is the future motion of the storm. Track prediction serves as the basis for forecasting other storm features, such as winds, rainfall, storm surge and the areas in the path. It is important to make judicious use of the advanced warning.

Step 6: Activate the plan: The hours just before a hurricane hits an area must be used wisely. The documentation of the facility under construction should be done routinely with digital pictures and video recordings. This will be useful to demonstrate the before/after impacts. All communication networks should be in working order. Protective materials (masking tape, plywood, lumber, etc.) should be readily available to start the mitigation actions. All trash and loose materials should be collected and contained to prevent them from becoming flying debris.

Because of high winds, windows of trailers and all other openings should be covered. Trailers should be placed in safe secured areas. It is important to secure the materials and to document of all the materials, equipment, and construction statistics. Back-up all the data on computers and even the paper documents should be kept at different locations to help preserve information. Secure materials in safe areas and install necessary bracing of masonry or exterior walls. Cover glass doors, windows with shutters, plywood, or other covering materials. Masking tape, waterproofing materials, or canvas can be used to help safeguard the windows or doors. Sheet metal and ductwork that has not been installed should be secured with wire rope to prevent it from being blown away. Remove all dumpsters or secure their contents. Scaffolding should be secured. Remove loose branches from the trees (if they exist) on the site. All the electrical equipment and electric cords should be unplugged. The company vehicles should be filled with gas and parked within a secure zone with parking brakes on. Remove vulnerable wood or metal signage to prevent them from being lost in the storm. The cranes, hoists and booms should be lowered and secured. Lockout/tagout all necessary equipment. The first-aid kit should be assembled and well stocked. The mitigation stage needs everything to be ready for the approaching hurricane.

Supplies for the preparation are as follows, but are not limited to:

- First aid supplies
- Plywood to cover openings and windows
- Battery powered AM/FM radio/weather radio
- Flashlights, and various kinds of spare batteries
- Miscellaneous tools: shovels, hammers, brooms, wet/dry vacuums, rope, drinking water
- Extra fuel for equipment
- Extensions cords, portable generators, sump pumps for dewatering
- Nails - assorted types, powder actuated fasteners
- Duct/masking tape, miscellaneous lumber - 2 x 4's, 4x4's
- Extra film for cameras and/or one use cameras
- Cleaning supplies
- List of emergency phone numbers
- Cell phones that are fully charged

Continually inform the facility owner and a contact person at the home office of the preparation status for the hurricane. The mobilization and demobilization plan needs to be ready at this stage. A carefully designed logistics plan will take care of the communication centers, transportation, facilities coordination, and resource tracking.

Step 7: Response: The foremost point in the response phases is for the team members to stay calm. However, the team should be alert and guard against panic and anxiety. All team members should stay inside during the hurricane until all is clear. Sometimes, there is a likelihood of a second hit by the hurricane after the eye passes, so care should be taken for such a situation. Battery radios could be turned on to monitor the outside situation. In case of evacuation, all employees should know the procedure and the exit routes.

Step 8: Recovery: The status of critical facilities, services, communication networks, public works and utilities, and transportation facilities should be quickly assessed as they need to be operational. The damage sustained by the project should be assessed promptly. This will be important as resources must then be allocated appropriately. Structures which have sustained serious structural damage must remain vacant until the structure has been restored under engineering supervision. The following points relate to the recovery phase:

- Recovery starts with a survey of entire site.
- Reconnaissance and observation of the damage to the site is a vital factor in the recovery stage.
- Timely removal of damaged and scattered materials should be performed with caution and care, where the search for missing persons or elements that can be saved or elements that can be salvaged should be carried out.
- Site cleaning activities should follow after expert analysis
- The environmentally acceptable disposal of debris and waste is required.
- The personnel, materials and equipment should be mobilized to restart the work.
- Continue to monitor radio broadcasts for news and instructions.
- Evaluate the integrity of gas lines and electrical circuits. Turning off the main gas valves, opening the windows, and sending the people outside are cautious steps to be followed.
- Cleaning off any kind of spilled liquids, agents of fire, bleaches, and gasoline must be done immediately and with caution.

Step 9: Post response assessment: Management should assess the construction site with the help of expert engineers. The planned procurement of supplies and inventory control should be addressed in this stage of the management plan. The following items should be performed with accuracy:

- Cost accounting and monetary estimates need to be developed for the recovery stage by the estimators and the management team in order to understand the project’s financial health.

- Identification of injured individuals and timely notification of family members to minimize the trauma to the victim's families should be done in a sincere manner.

- Filing applicable workers' compensation claims is the responsibility of the company.

- Thorough evaluation of the destruction should be done. Also, the damage on the construction site should be documented with photographs or video records for comparison with the previous records.

Step 10: Share lessons learned: The lessons learned in the post response assessment phase should be shared among the team members to determine what modifications would strengthen the plan. The evaluation of losses in monetary and productivity units could be shared with the management team, so as to create a new plan for full recovery

Step 11: Credit the efforts: The acknowledgement of the efforts of all the team members should be done shortly after the hurricane has subsided. The continuation of business involves strengthening the morale of those involved in the response and rescue operations. "Credit the efforts" could be summed up with the following points:

- Recognize the efforts and successes of site personnel
- Console the adversely affected individuals

Step 12: Evaluate need for change: By using the information gained in the post response recovery and the lessons learned, an evaluation can be made regarding the need for further modifications of the plan.

Step 13: Modify the plan: The reinforcement of the plan with positive changes makes the hurricane management plan well suited for future hurricanes. The only remedy for the natural crisis/disaster is to prepare a stronger defense system, thus planning more effective response measures. The anticipation of hurricanes with well prepared drills and simultaneous modifications can save lives, material, money and resources.

Case of Earthquake

Step 1: Potential crisis/disaster identification: It is almost impossible to predict an earthquake, but certain geographical locations are at greater risk than others. In earthquake prone areas, an earthquake can happen any time of the year without warning. The earthquake can be felt by a series of wave-like vibrations, which travel through the earth's crust.

The classification of earthquakes is characteristic of their depth:

- Shallow- less than 70 km deep
- Intermediate- 70-30 km deep
- Deep- more than 300 km deep

There are no earthquakes known to take place below a depth of 720 km.

While little can be done to anticipate an earthquake, the earthquake management plan can effectively address the post-event response phase.

Step 2: Risk assessment: After it is recognized that the region is in a high probability earthquake zone, the next step is to make risk calculations. The risk could be calculated by determining the phase of the construction project (most vulnerable to damage), probability of occurrence of an earthquake and the related consequences. Planning for the earthquake requires management to understand earthquake characteristics. Certain earthquakes have hardly noticeable vibrations, whereas others can have catastrophic affects. Based on risk assessment, it might be determined that the risk is sufficiently serious and that an earthquake is likely to occur. Under these conditions, a management plan for an earthquake should be developed.

Step 3: Develop and implement plan: The plan should be divided into three different categories,

Step 3a: Plan for the pre-event phase. Before an earthquake occurs, the pre-event planning for the response systems is as follows:

- All upright furniture and other heavy objects on the shelves should be secured or placed on the floor
- All heavy substances should be fastened at the lower levels in cupboards or closed boxes
- Tightly secure the water heaters, gas and oil heaters
- Gas pipes, MEP systems, electrical wiring should be in good condition to reduce potential risk of fire

Step 3b: Plan during the event. When an earthquake strikes, with workers inside buildings, they should position themselves under sturdy furniture, such as heavy desks or against an inside wall. The workers should not leave the structure during an earthquake, when the danger of heavy objects or masonry falling is high. If workers are outdoors, they should move away from structures, canopies, overhead construction, cables and projections. They should then gather in a predetermined location.

Step 3c: Plan for the post-event phase. Earthquakes might impact a construction site for only a short time. Ground shaking and rupture are the main effects created by an earthquake, where it principally results in more or less severe damage to buildings or other rigid structures. So, all the site personnel should not touch any power lines or damaged structures. After a complete site examination by the expert engineers, management can determine when to restart the construction activities.

Step 4: Drills, evaluation of drills: Drills conducted on the construction site should be instantaneous responses by all site personnel. While the responses are simple and only take a few seconds or minutes, judicious attention to protocol is important. Evaluations of the drill require the site personnel to strengthen the plan, if needed, by modifying it with further changes.

Warning/no warning. Accurate warnings are not possible for earthquakes. Sometimes the earthquake will be followed by aftershocks in the following hours or days. Otherwise there is no warning. The initial earthquake could be an indication of aftershocks in the following hours or days. Otherwise, there is no warning.

Step 7: Response: The only major response possible in the case of an earthquake is to calmly move towards the safe zone as described above. The steps to be taken will depend upon the intensity of the earthquake and also the structure's resistance to vibration which can save the constructed facility from collapse.

Step 8: Recovery: It is important to understand that an earthquake can have secondary effects and a second round of shaking after just a few seconds, minutes or hours. Smaller earthquakes may also foretell large earthquakes in the future. Therefore, team members should stay away from the proximity of structures when outdoors. Calling the emergency services and communicating with all the internal team members is the next step.

Step 9: Post response assessment: Management should evaluate the management plan after an earthquake has occurred. It is important to understand the mistakes in the earthquake management plan so that similar destructive results might be avoided in the future.

Step 10: Share Lessons learned: If the earthquake is mild and with no serious damage, it could be assumed that the performance of the construction process will succeed in its pursuit of successful completion. It should be kept in mind that errors in planning should not occur. Actions during the response phase should be evaluated. Forensic engineers can observe and analyze the scope and causes of the damage done to the construction site. The geologists studying the epicenter and the influencing radii of the earthquake can make predictions of the probable reoccurrence in that geographical location. The company responsibility is for the safety of the facility, material, equipment, workers and money.

Step 11: Credit the efforts: The rescue operations within the site and in the community should be credited with top management involvement. One of the key issues to examine will relate to the avoidance of unseen injuries and the minimization of property damage.

Step 12: Evaluate the need for change: The feedback provided by the earthquake management plan, especially in the post response assessment and lessons learned phases will provide valuable information about the need for plan modifications.

Step 13: Modify the plan: Modifications to the plan should be made if changes and suggestions by the post response assessment and lessons learned phase.

Case of On-site Fall

The identification of an injury hazard on the jobsite is a safety issue to be addressed by management. The top four causes of construction fatalities are: falls, struck-by, caught in-between, and electrocution. Each of these causal factors should be considered.

Step 1: Identifying potential crisis/disaster: The company history of working on a high rise construction project and its consequent incidents of injuries could be the first step to watch for similar events ahead. Then the potential of injuries during the construction of the project could be estimated. Despite predictions of low injury occurrence, there is always a chance of an injury. Whenever work is performed at elevation, the chance of a fall is always present. To address this, a company might implement a 100% tie off policy for all work performed above the elevation of six feet. Workers being tied off does not ensure that workers will not fall, but that they will be restrained from falling by the use of a harness. Even though a worker might be “saved” by wearing a harness in a fall, a quick rescue is still required. A worker suspended by a lanyard for an extended period of time could still result in a serious injury or even death.

Step 2: Risk assessment: The risk assessment for the injuries related to falls, when workers are tied off, consists of the probability of occurrence and the severity of the consequences. While no level of accuracy can be claimed in the computation, the key issue is that there is a possibility of injury and it can be addressed with the allocation of few resources. Enumeration of different factors contributing to the probability of occurrence is a crucial task at this stage. The correct method of wearing the harness corresponds to the low or high risk of an injury during a fall. The attachment of the lanyard near the center of gravity makes the fall position safer for the worker.

Step 3: Develop and implement plan: Since the probability of the occurrence of a fall is high and since the consequences of a fall can be serious, a management plan for the rescue of a worker who has fallen with the use of a harness and lanyard needs to be prepared. The avoidance for all kinds of injury incidents should be the goal of every construction company as safety should be a core value. This effort can also save money on a construction project. While many safety parameters should be employed, this plan will focus specifically on the rescue of a worker who has fallen and who is suspended by a lanyard. The plan could be divided into three categories:

Step 3a: Plan for the pre-event phase. In the pre-event plan the following preparations should be made:

- Workers should always wear personal protective fall arrest equipment
- A crane or JLG should be located in the general vicinity when elevation work is performed
- Install and maintain perimeter fall protection
- Floor openings should be covered and labeled
- Ladders and scaffolds should be used safely

The safety management team needs to be organized to make arrangements for the hour of need. A key factor in a fall rescue is timeliness. If the method of wearing the harness is inappropriate; all the efforts to save the worker could be in vain. It is important that the harness is comfortable but not interfere with the task completion. The length of the lanyard is also an important consideration. A shorter lanyard would put less stress on the body at the time of the initial fall. A moveable safe anchor could be used, but it is not available for all construction processes. Cranes could be helpful in rescuing a worker after a fall. All the communication networks, internal and external, need to be documented in the company diaries. Emergency response systems should also be tested.

Step 3b: Plan during the event. The site personnel should inform the supervisor or site management about the occurrence of a fall. The worker under suspension should try to maintain a position with the legs slightly raised. Cranes or other equipment should be employed for the worker's rescue.

Step 3c: Plan for the post-event phase. The worker tied to the lanyard and harness should be carefully transported to a safe area. The worker being suspended should be asked not to stand up, but should be asked to sit for some time and then gradually be taken to a normal position. The internal body mechanism of the worker needs to be slowly revived to normal status.

Step 4: Drills & evaluation of drills: When a worker falls while wearing a harness and while being tied off to an anchor, the worker will generally be uninjured but suspended. At the moment a worker has fallen, the incident should be called to the immediate attention of a supervisor or the safety manager. The posture of the person who has fallen is unpredictable but this plays a crucial role in the worker's probability of suffering from suspension trauma. Fall victims can slow the onset of the suspension trauma by pushing down forcefully with the legs, by positioning their bodies in a horizontal position, by slightly elevating the legs or by "standing up" in the harness. The response of the rescue team needs to occur immediately as every single second is important in the battle for life. The worker should be taken out of the suspended position and should be gradually taken to a normal standing position. Caution should be taken to keep the worker from standing up as high blood pressure release could consequently result in death. Any mistakes or shortcomings of the rescue drill should be recognized and corrected in the modified plan.

Advanced notice: The advanced notice on a construction site about falls is not apparent as incidents occur mostly without any previous signs. However, the contributing behavior of the worker (substance abuse, medication, risky behavior, etc.) may be seen as a predictive incident. In most cases the prediction of such an event is difficult.

Step 7: Response: Once a fall has occurred, the project should immediately actuate its rescue plan. The attention by the co-workers during the construction activities can save a life. The rescue consists basically of getting the assistance of a crane or other similar piece of equipment. The crane can then be instrumental in getting the worker down in matter of minutes.

Step 8: Recovery: The rescue must take place swiftly to minimize the danger of suspension trauma. The lanyard attachment point and the manner of handling the harness determine the effects of the fall. If timely help is not provided, a worker can lose consciousness. The important helping aid could be to move the person from the kneeling to a sitting position to a supine position for half an hour to forty minutes.

Step 9: Post response assessment: If the worker has been taken out of the life-threatening phase and circulation of blood has come to a normal level, the plan could be deemed successful. The efficiency of the system should be assessed for this step. It is important to understand the time taken to rescue a person. Safe handling of the fall victim and an immediate normalcy response must be studied to draw conclusions about the need of additional modifications to the plan.

Step 10: Share lessons learned: The drawbacks or advantages of the fall rescue plan must be shared with the management team. The need to provide further training to maintain an effective response should be shared with all appropriate personnel. Even with an effective fall rescue plan, efforts should be sustained to avoid such fall incidents.

Step 11: Credit the efforts: All the site personnel associated with the response phase need to be credited for their efforts and should remain prepared for such a crisis event in the future. Efforts should be made to elevate the morale of all site personnel.

Step 12: Evaluate the need for change: The drawbacks, technical limitations or performance weaknesses must be evaluated for the safety of the construction team. It is important to understand that modifications can improve the fall management plan. If the preparations had shown success, then there is no need to change the plan.

Step 13: Develop modifications: If there are evaluations stating that the emergency planning is lacking in the proper functions of the rescue operations, modifications should be made in the preparatory plans. Saving a life is important to boost the morale of the team and maintain the reputation of the construction company.

CHAPTER 5
CONCLUSIONS

Various kinds of calamities can affect a construction project. Some calamities might take a while to impact a construction project, while others might take a very short time to strike. Also, sometimes it is not possible to estimate the consequences prior to the crisis/disaster event. For example, a minor crisis/disaster event might have tremendous consequences, while a major crisis/disaster event might not have any impact on the construction project at all. Regardless of the kind of crisis/disaster or its consequences, a common way of addressing the various kinds of crisis/disaster events was developed. Crisis/disaster events at construction projects can be effectively addressed with management plans being prepared with the use of the CCDM model.

In order to determine whether the model is applicable to different kinds of crisis/disaster events, different tests were conducted to examine its validity. The CCDM model showed applicability to all the crisis/disaster cases. The networking within different levels of the Construction Crisis/Disaster Management (CCDM) model establishes the fundamental solution for all kinds of crisis/disaster events on construction projects. Although specific actions at every level of the model might vary, the fundamental organization of the CCDM model will remain the same.

CHAPTER 6
RECOMMENDATIONS

All units of a company or even different construction companies should work together to create common solutions for common problems. If incorporated into the management processes, the widespread use of this model could save considerable resources, including money, materials, labor and reputation. Without advanced planning or just ignoring standard practices, such as the Construction Crisis/Disaster Management (CCDM) model, the actions in response to a crisis/disaster would be little more than a random selection of actions.

The computer simulation of realistic 3D space models could be created to demonstrate the magnitude of major consequences of construction crisis/disaster events. Computer simulated models can analyze the merits of preparatory methods in various terms such as structural, material, labor, financial, productivity and other elements in the context of the construction projects.

If possible, then the crisis/disaster management plan should be coordinated with the emergency plans of the local, state and federal governmental agencies. The CCDM model could also be used in making preparations for national and international crises/disasters, thus improving a nation's capacity to address all crises/disaster events.

It would benefit all the managers in the construction industry to prepare against various crisis/disaster events. The result of this research provides a platform for the future establishment of coordinated, direction-oriented and integrated response systems for future crisis/disaster events that might impact construction projects. Also, the managers of construction companies could review the CCDM model with their respective projects and made decisions about the development of specific crisis/disaster management plans.

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BIOGRAPHICAL SKETCH

Deepak Sharma received his Bachelor of Architecture from Guru Nanak Dev University, Amritsar, India. After working for 4 years, he was selected for education in the M. E. Rinker, Sr. School of Building Construction, University of Florida in 2005. His interest in the construction and development fields with architecture as the focus, enthused him to research various subjects related to engineering, science, and arts. He will continue to study and apply the scientific approach to the construction field.

Deepak Sharma was born in Jalandhar, India. Upon graduation he plans to continue working in the construction industry. He will focus on economic solutions for the construction industry, most affordable housing, and safer construction practices for the international community.