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Hurricane Preparedness in a Construction Site: a Framework to Assess the Construction Companies' Current Practices

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HURRICANE PREPAREDNESS IN A CONSTRUCTION SITE: A FRAMEWORK TO ASSESS THE CONSTRUCTION COMPANIES' CURRENT PRACTICES

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Michelle S. Chávez

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To: Interim Dean Ranu Jung
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This thesis, written by Michelle S. Chávez, and entitled Hurricane Preparedness in a Construction Site: A Framework to Assess the Construction Companies' Current Practices, having been approved in respect to style and intellectual content, is referred to you for judgment.

We have read this thesis and recommend that it be approved.

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Vice President for Research and Economic Development
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Florida International University, 2016

DEDICATION

I dedicate this thesis to my parents Miguel Angel and Beatriz. I hope that this achievement makes you prouder, it's a sample of all the hard work I have been through to complete my Master's program in the US. Thank you so much for your support in spite of the physical distance that separates us, and for always giving me the comforting word that I needed during the darkest time.

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ABSTRACT OF THE THESIS

HURRICANE PREPAREDNESS IN A CONSTRUCTION SITE: A FRAMEWORK TO ASSESS THE CONSTRUCTION COMPANIES' CURRENT PRACTICES

by

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Florida International University, 2016

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Professor Youngjib Ham, Major Professor

Civil infrastructure construction sites including incomplete structures and unsecured resources are among the most vulnerable environments to hurricane conditions. Hurricane driven damages cause disruption of construction sites and considerable schedule delays, and thus negatively impact the efficiency of the construction projects. This research aims to study current best practices on securing construction sites from hurricane conditions and evaluate the performance of the preparedness plan. To do that, first, an interview-survey is conducted with key project personnel from multiple construction companies. Then, the insight from the interviews serves to do a Micro and Macro Environmental Analysis. For further analysis, a Balanced Scorecard is used to suggest metrics to measure and improve the performance of the Hurricane Preparedness Plan. The findings from this research improves the organizational processes and enhances the assessment of disaster preparedness, which ultimately generates new and highly specific knowledge on disaster mitigation and preparedness guidelines for construction sites.

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1. INTRODUCTION

Hurricane losses in the United States have ascended to billions of dollars in property damages, where Hurricane Katrina recognized as the costliest natural disaster produced an aftermath of $108 billion. In the state of Florida, Hurricanes Andrew and Wilma caused damages between $21 and $27 billion respectively (Blake et al. 2011). The outcome of these events negatively affected civil infrastructures in operation as well as unstructured construction sites including incomplete structures and unsecured resources (e.g., materials, equipment, and temporary facilities). For example, 2012 Hurricane Sandy caused over $185 million worth of damages to the World Trade Center construction project in New York City (Fermino 2013).

Current ordinances, regulations, and building codes in the construction industry; mainly focus on the design of more resilient structures. Also, construction companies located in hurricane prone-areas typically protect their job sites by the application of extreme wind preparations. In addition, regulatory agencies such as the Occupational Safety and Health Administration (OSHA) continuously work in the supervision of construction companies and their vulnerable construction environments. In general, assessment of hurricane preparedness (HP) is based on agencies' general standards that are improved following experiences of industry professionals. Therefore, the entire responsibility relies on the contractors in terms of the design, implementation, and monitoring of the on-site hurricane preparedness plan (HPP) for construction projects.

This research aims to study current practices on securing construction sites from extreme wind events such as hurricanes. Also, this study intends to analyze the related organizational issues and then propose a framework that allows to evaluate performance in construction projects. First, rigorous literature reviews are conducted to understand prior hurricane preparations and the main criteria used to measure performance. Subsequently, intensive interview-surveys are conducted with key project personnel from multiple construction companies to understand current operational protocols, best practices, and issues on disaster preparedness plans in construction sites. Then, the insights from the domain expert evaluations are fed into the micro environmental analysis of the problems, and this task is followed by the macro environmental analysis. For further exploration, a balanced scorecard is used to suggest objectives and metrics to improve the performance of disaster preparedness plans of construction companies, this in terms of the following four perspectives: (1) the Internal Process Perspective, (2) the Learning & Growth Perspective, (3) the Customer Perspective, and (4) the Financial Perspective.

This research is likely to help practitioners to integrate industry professionals' experiences as critical factors that finally monitor the performance of disaster preparedness. Also, the findings of this study have the potential to contribute to specialists a better understanding of the need to apply strategic measurements or performance indicators to assess the disaster preparedness of construction projects. This work allows the possibility to improve organizational processes enhancing the assessment of HP, which ultimately generates new and highly

specific knowledge on disaster mitigation and preparedness guidelines in construction sites.

2. LITERATURE REVIEW

2.1. Hurricanes Meteorological Background

Storm systems include tropical cyclones characterized by a low-pressure system and thunderstorms that produce strong wind and flooding rain that occurred in tropical regions (Strobl 2011). Depending on their location and strength, the systems are referred by other names such as hurricane, typhoon, tropical storm, cyclonic storm, and tropical depression (Strobl 2011). A hurricane is defined as a rotating mass of wind that circulates around a calm center called the eye, which is surrounded by rain bands that extend in spirals. Hurricanes are potent forces which duration can last for more than two weeks over water and can spread across 400 miles. Also, they are large-moving storm systems that can affect entire states or regions among coastal development and inland areas (Schwab et al 2007). The hurricane season in the Atlantic, Caribbean and Gulf of Mexico area ranges from June 1 to November 30 each year (Allianz 2011). According to the Saffir/Simpson Hurricane Wind Scale (SSHWS), hurricanes are classified in 5 categories depending on certain wind values: (1) 74-95 mph (2) 96-110 mph (3) 111-130 mph (4) 131-155 mph (5) > 155 mph.

2.2. Hurricane Preparedness in Construction Sites

Natural disaster studies related to the construction field have revealed that for a $1 invested in prevention, $40 of loss are reduced (Pheng et al. 2006). Therefore, construction sites protected with robust preventative planning mitigate potential

damages due to inclement weather. Construction sites have incomplete or temporarily supported structural systems, and additional resources such as loose materials and construction equipment are extremely susceptible under extreme wind conditions. Moreover, construction debris under heavy winds become projectiles and damage building envelope components (e.g., windows, doors, roofs) that even if secured could allow water to penetrate. Likewise, a storm surge can flood and damage foundations, retaining walls, and low-lying structures. Furthermore, equipment such as cranes can collapse or be damaged by high winds or flying debris (Allianz 2011).

Construction companies that operate in the hurricane belt are highly aware of the impacts that hurricanes cause to construction sites. However, contractors typically do not operate in advance and implement the precautions when a hurricane is imminent (Allianz 2011). This is assume to occur due to the lack of an efficient organizational culture and unawareness of the importance of a HPP.

There is limited information regarding hurricane impacts to construction sites, in general the available information relates to the aftermath of construction projects. For example, previous works have shown that about 1.1 percent of U.S. total permit authorizations of the construction activity were impacted by hurricane Katrina (U.S. Census Bureau 2004). Similarly, Mc Graw Hill Construction pointed out that the New Orleans Convention Center construction project had damages of $275 million by hurricane Katrina. Likewise, hurricane Sandy during 2012 severely impacted New York City leaving an aftermath of $71.4 billion which included the

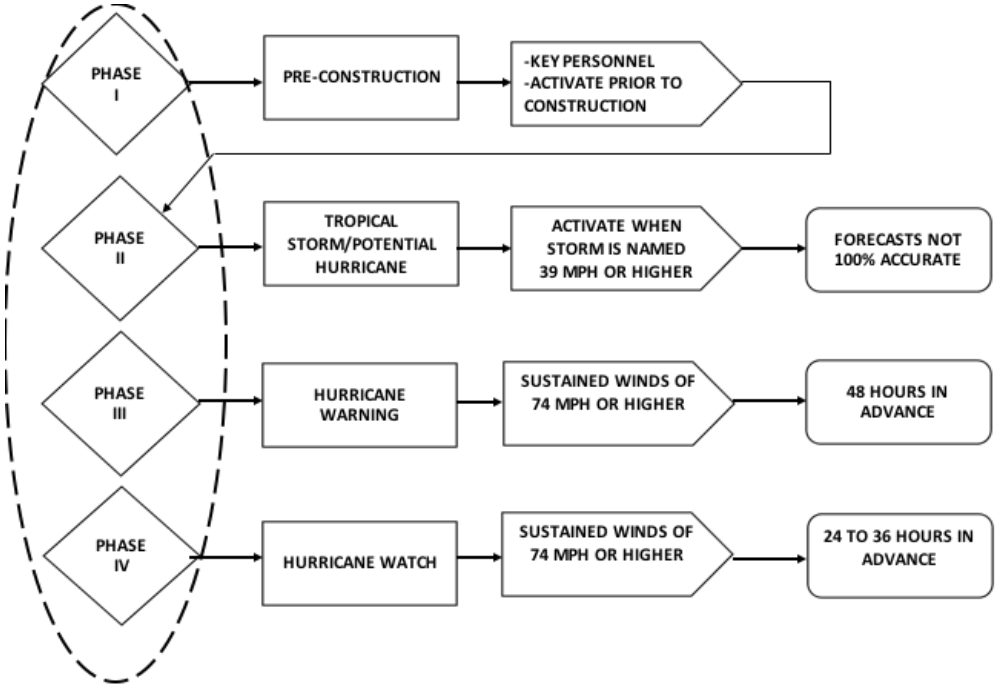
Midtown Manhattan 74-story skyscraper project that was under construction. The major issue was the boom of the tower crane that collapsed. In the case of Miami-Florida, hurricane Wilma impacted the Miami International Airport South Terminal construction project leaving a total damage of $4,199,192 (FEMA 2012).

Despite the use of resources (e.g., automated forecasting, satellite-based estimates, computer and communications systems, wind speed monitors) to monitor construction sites from hurricanes, weather uncertainty prevails as a prime factor towards robust HP. Nevertheless, the industry professionals perform daily observations following the HPP recommendations for construction sites. Additionally, for a complete and correct hurricane program implementation, there is the need for construction companies to revise their internal processes and be aware of how organizational procedures and participants-behaviors may influence HP.

2.3. Insurance Companies Preparedness Recommendations

Insurance companies' contribution to HP is related to the recommendation of hurricane preparedness procedures that are part of the Hurricane Action Plan. Also, this hurricane plan includes check lists formats that help to monitor the preparation of the resources in the construction site. These precautions should be implemented even if the construction project is not directly located in the predicted path of a tropical storm. Hurricane actions plans include four phases regarding the preparations before the storm, figure 1 shows the different phases:

Figure 1: Hurricane Preparedness Plan Phases (Allianz Global Corporate & Specialty 2011).



This research focuses on the organizational processes that affect the current practices to prepare construction sites from hurricanes. Thus, this study analyzes the factors and issues related to the best practices of the HPP. Each phase of the Hurricane Plan aims to address all the on-site preparations in advance of the extreme wind event. Also, these precautions require to be adjusted according to the project-specific scenario or the local requirements. Subsequently, the collection of best practices that should be part of a HPP include (Allianz Global Corporate & Specialty 2011):

(1) Phase I - Pre-construction: This phase is activated prior to construction and before hurricane season. In general, the recommendations are:

- Have a person in charge of the plan implementation that has the control during the emergency and assigns emergency responsibility roles.
- Develop the Hurricane Response and Recovery teams.
- Have an emergency phone list for all key personnel and subcontractors.
- Meet, review, and discuss the Hurricane Action Plan, the team members' roles and responsibilities.
- Assign responsibility for monitoring the weather and tracking the storm when is named.
- Think of possible project scenarios and specific courses of action for each.
- Develop an inspection and testing schedule for emergency equipment.
- Establish treaties with contractors, subcontractors, and suppliers.
- Establish contracts prior to hurricane season with pre-negotiated rates.
- Perform pre-planning with local authorities.
- Establish procedures to follow in the event of exposed energized electrical wires, flammable or hazardous liquid leaks, leaking gas, structural damage and utility damage.

- Make provisions for security measures, salvage, and cleanup operations.

(2) Phase II – Tropical Storm/Potential Hurricane: During this phase weather forecasts are not 100% accurate. Consequently, precautions should be implemented even if the construction site is not directly in the projected path of the tropical storm. This phase is activated when the storm is named and wind speeds are of 39 mph. In general, the recommendations are:

- Review the Hurricane Action Plan and update if required.
- Conduct a project meeting and review and confirm action items with the individuals responsible.
- Monitor material deliveries and foresee the impact of material deliveries and the potential of stopping deliveries.
- Determine material required to protect the site (e.g., plywood, netting, banding, plastic sheeting, trailer anchors, and tie-downs, concrete anchor screws).
- Secure the jobsites (e.g., protect/secure materials and equipment, cover exterior openings, complete structures, brace equipment, clean site, etc.).
- Update the project's Critical Path Method (CPM) Schedule Logic Diagram. This is useful to determine the project's pre-storm status and later establish the delays caused by the storm, damages and repairs.

(3) Phase III – Hurricane Watch: This phase is activated 48 hours before the storm and anticipated sustained wind speeds of 74 mph or higher. In general, the recommendations are:

- Stop all material deliveries.
- Have subcontractors move any uninstalled materials to a safe location.
- Discontinue works on parts of the project that would be vulnerable to damage by extreme wind-related events.
- Complete work if it would minimize the impact of a storm event (e.g., roofs, openings).
- Protect materials or equipment that cannot be moved (e.g., brace, secure, band, bundle, elevate materials 4 inches above the floor).
- Cover exterior openings (e.g., doors, windows, roof openings).
- Close all doors and windows.
- Remove, secure, isolate or neutralize chemicals to prevent any release or reaction.
- Anchor and tied down all construction trailers, shipping containers, or storage boxes.
- Remove loose jobsite materials and debris that could become projectiles.
- Remove or secure with nets dumpsters/garbage containers.
- Relocate important documents and records to a safe location.

- Finish work on partially completed structures to minimize damages.
- Brace/secure if completion of structures is not possible.
- Remove and secure formwork if it cannot be filled with concrete (e.g., secure using heavy structural steel components and banding).
- Prepare structures to prevent water damage (e.g., grading, sandbagging).
- Have a design engineer examine and advise how to minimize potential damage to the structures.
- Remove scaffolds when possible. If removal is not feasible, remove and secure all boards. Secure all mobile scaffolds to columns or place them in shipping boxes.

(4) Phase III – Hurricane Warning: This phase is activated less than 24 to 36 hours before the storm, and during this stage there are sustained wind speeds of 74 mph or higher. In general, the recommendations are:

- Secure all exterior building openings, doors and windows.
- Minimize the infiltration of water into the building and excavations (e.g., install protective measures such as grading, berms, sandbags, pipe caps).
- Address housekeeping items such as debris removal from jobsites.
- Secure materials that cannot be moved by placing them in interior building locations or bind them.
- Make sure that all roof drains are operational.

- De-energize power at the circuit breakers as close to the main power breaker as possible.
- Shut down all gas lines and water lines that are not used for fire protection.
- Secure/protect fuel tanks and drums to prevent movement and damage.
- Remove or secure portable toilets.
- Prepare flood cofferdams if it is the best option for damage reduction.
- Implement building code requirements governing hurricane and high-wind preparations for cranes and hoisting equipment.
- Remove portable equipment from jobsites, or store it in shipping containers.
- Backfill excavations if feasible.
- Remove fence screening, signs, and banners.
- Document with video and photographs jobsites and surrounding properties (project condition and status prior to the storm).
- After securing the construction site, instruct subcontractors and employees to vacate the jobsite and return after the danger has passed.

2.4. State Agencies Preparedness Recommendations

After hurricane Sandy devastating consequences, the New York City Department of Buildings enforced preparedness regulations that contractors must complete as part of their liability. These should include but not be limited to the following constructions components (NYC DOB 2013):

(1) In general construction:

- Construction materials and debris should not be stored closer than 10 feet to the perimeter of the building.
- Masonry walls under construction or repair should be shored and braced to prevent collapse under wind load.
- Steel structural elements should be brace and/or shore as well as secure with positive attachments (e.g., mails, bolts, welds). In the case of planks, metal decks, wood floor, and roofing; uplift should be prevented by weighing down the elements with sand bags or brick pallets.
- Unfinished building enclosures installation should be stopped in advance of wind events.
- Concrete construction that includes formwork should be removed if it is not weighted down by concrete, other concrete works should have nailed or bolted connections.

(2) Temporary installations:

- Must be designed for wind conditions where not engineered structures should be removed.
- Perimeter netting or guardrails shall be cleaned of debris, inspected and properly secured.

(3) Other construction components:

- Scaffolds, construction fences and barriers, and material and personnel hoisting equipment should be properly secured or follow the manufacturer standards to operate under wind conditions.

2.5. Construction Companies Preparedness Recommendations

Construction companies working in hurricane prone areas have the obligation of including the HPP as part of the construction projects. This plan is based on the recommendations of insurance companies and state agencies regulations. Additionally, companies must adjust the hurricane programs to each project complexity and geographical location. The following information was obtained from the hurricane programs provided by six different construction companies. The documents were reviewed and classified into thirteen elements, where main actions are identified as part of the logistics to secure construction sites:

1) Weather conditions – On a daily basis construction companies monitor the winds by the use of technologies such as weather applications or weather websites. Also, under high wind conditions, a common practice it to stop heavy equipment operations (i.e., cranes). Weather conditions are

uncertain and influence contractor´s final decision on whether applying or not costly preventive measurements.

2) Equipment – Vulnerable equipment under high wind conditions in construction sites include: cranes, yarders, hoists, scaffolding systems, hanging scaffolds, generators, dewatering pumps, outriggers. Securing actions consist of sandbags to weight down the equipment or to construct berms in low-lying areas of the site to relocate the equipment. In addition, the manufacturer´s operation manuals are used to prepare the equipment for heavy wind conditions.
3) Temporary structures and controls – The following elements must be properly attached, nailed down, or reinforced to withstand heavy wind conditions: fences, barriers/barricades, signage, sidewalk bridges, perimeter netting, guardrails, gates, pedestrian walkway, sound blankets, tarps, and hoist ways.
4) Loose building materials – These elements deserve special attention since under high wind conditions they become airborne and cause serious damages in construction sites and surrounding communities. Materials in this classification include: piles of gravel, plywood, sheetrock, lumber, formwork, and steel erection. Measures comprise proper storage and monitoring material deliveries to be cancelled if programmed during the hurricane warning.
5) Housekeeping/site cleaning – The following elements also become airborne under high wind conditions: loose trash, debris, storm drains/catch basins,

excess/nonessential building materials. For robust management of these elements, the site should be cleaned in a daily basis to prevent the accumulation of unnecessary resources. Also, housekeeping is important to prevent the obstruction of elements that should be functional during a storm (e.g., drainage systems).

6) Building/enclosures – The following elements are very sensitive to high wind conditions and shall be secure to resist high wind speeds: doors, windows, roofs, stairs, exits, floors, and mechanical and plumbing elements. Moreover, unpoured concrete structures should be load with elements to prevent uplift of any component or remove the formwork if possible.
7) Excavations/holes/trenches – All earthworks under high wind conditions should be secured by the installation of shoring systems, and excavations should be filled back with materials if possible. In addition, any excavation or trench should be changed in geometry by cutting the recommend slope or by benching berms to reduce the risk of possible collapses. Another important recommendation is to dewater all excavations to reduce the damages that a combination of water and wind can produced.
8) Temporary facilities/utilities – This includes the following elements that shall be secured to prevent uplifting during extreme wind conditions: temporary trailers, temporary offices, storage areas, dumpsters, portable toilets, and Siamese connections. Additionally, the following utilities are to be suspended ahead from extreme wind events: electrical power, and water

service. Power feeders and power panels are also elements that should be properly attached.

9) Personnel – The following represent elements and actions to implement as part of the organizational processes of the HPP: personnel call list and notification by the use of different media, superintendent/project manager involvement as leaders, check sheets to assess the preparedness plan, walk through/inspections, subcontractors' compliance, schedule/hire laborers for emergency works, and schedule superintendents for emergency works.

10) Environmental aspects – This refers to the management of chemical and fuel releases in construction sites. Under high wind conditions or during a hurricane, leaving these contaminants can cause serious damages and accidents.

11) Insurance – When planning ahead of a storm, the insurance policy should be reviewed and for an effective coverage the insurance agent should be notified of the preparations to reduce the damages. In addition, construction sites should be documented with photos and videos as proof of the preparations.

12) Contract issues – Some recommendations that are related to the construction contract include: negotiating contracts with subcontractors in the case of severe wind events, contracts outside company for hurricane estimates to be aware of the costs that the preparations might have, and

notify the owner about the delay due to preparations and clean-up of construction sites.

13) Other preparations – This includes: notify local authorities, implement fire safety procedures, have ready the emergency supplies for the field and office, fuel all vehicles, remove all office equipment and furniture, files, plans to safe locations, empty and clean refrigerators in field offices, and evacuate site when winds are greater than 40mph.

2.6. The Balanced Scorecard

During heavy winds season where hurricanes are likely to occur, unsecure resources in construction sites represent concerns to construction companies. However, to implement complete and correct preventive measures, construction companies' processes and employees must be aligned to the organization´s HP policies. Consequently, the organizational processes and the level of performance that a company has are of high importance to prepare and protect efficiently jobsites from natural hazards such as hurricanes. Thus, this research focuses on the analysis of the organizational problems that the construction companies have by applying the Balanced Scorecard approach (BSC).

2.6.1. BSC Concept and Perspectives

The Balanced Scorecard (BSC) was first introduced by Kaplan and Norton (1992), this performance measurement approach has two different applications. Initially the method was developed to check the performance status of a business organization, and further managerial requests made the tool applications to evolve for project management (Stewart 2001). Through the application of the BSC, project managers can identify problem areas in projects or programs of natural disaster management that require improvement, and as a result an effective and efficient implementation of the plan is possible (Tun Lin et al 2007). In the case of this research, the BSC is used to analyze the issues on the HPP that construction companies have regarding robust plan implementation.

The BSC framework increases awareness among managers and utilizes measures that are adopted to improve the performance. The basic principle is to relate these measurements to the strategies that are proposed to improve the processes. Moreover, a common practice that executives have is to use short-term financial indicators (e.g., return-on-investment, operating income) to measure the performance of strategies and processes. However, the aim is to introduce different indicators (i.e., measures) relevant to the new initiatives (i.e., objectives) that the organization should activate for improving performance (Kaplan and Norton 2000). Hence, the measures on the BSC are used in the business organization to articulate and communicate the strategy, and to achieve common goals by aligning individual, organizational, and cross-departmental initiatives

(Kaplan and Norton 1996). Subsequently, the scorecard analyzes four different perspectives: (1) the management perspective, (2) the customer perspective, (3) the internal business perspective, and (4) the learning and growth perspective. For each perspective, strategies and objectives are established and then measures are selected. Traditional financial measures are complemented with the strategic measures of performance selected for the remaining of the BSC perspectives (Kaplan and Norton 1996).

To asses HP, this research contemplates the information written in the hurricane programs provided by construction companies. Also, this study includes for the analysis other factors that are presented further and that represent issues that should be reduced or eliminated for a robust hurricane program implementation. Therefore, to evaluate the preparedness, this material in conjunction with the four perspectives of the BSC are applied.

According to Kaplan and Norton (1996) the BSC perspectives contemplate:

(1) The Management Perspective (Financial Perspective) – The objectives and measures selected in this perspective serve as the focus in all other perspectives. This means that a cause-and-effect relationship exists between all the measures selected for the system, which intends to improve the financial performance of the organization.

Management commitment and involvement is the most important factor for achieving satisfactory performance (Mohamed 2003). Consequently, the

enhancement of organizational culture is dependent upon the deliberate manipulation of various organizational characteristics and activities that impact management practices. In addition, for this perspective the following question should be answered to assist the establishment of performance measures in the particular case of disaster preparedness: What must management excel at to achieve “zero” damage in property, accidents, and production downtime?

(2) The Customer Perspective – This perspective influences the outcomes of the management perspective strategic objectives and metrics. Also, companies should achieve that their service delivery is of great value to all customers. For instance, by incorporating on their planning all the preventive procedures to secure a construction project from natural disasters such as hurricanes. Additionally, managers should translate the strategic statements into customer-based objectives, and at the same time these should be communicated throughout the organization.

The BSC includes in this perspective two groups of customers: the client and the employees. Clients, are customers that have special preferences and value the attribute of the service differently. Employees, in the case of the construction industry, include the employees of the organization and project partners such as subcontractors.

This perspective, in the particular case of disaster preparedness, reflects the following question: Compared to competing companies, how do customers see the company in the context of being prepared? (Mohamed 2003). Furthermore, the measurement group used for this perspective may include metrics which relate to customer retention and customer satisfaction. Where, customers´ preferences are not always related to safety, hence, the key is to develop a strategy that convinces them of the importance of preparedness in the overall performance of projects (Kaplan and Norton 1996).

(3) Internal Process Perspective (Operational) – This perspective strongly relates to the strategy implementation. The principal objective of this perspective is to strengthen the program through addressing operational activities such as maintaining the working environment into a safe workplace, improving working relationships, and being proactive in detecting any omissions. Nonetheless, the fact that these activities may not be measurable in all cases still affects the achievement of the management perspective objectives. The following question explains the purpose of the internal perspective: What must the company do to ensure the efficient implementation of preparedness procedures? (Mohamed 2003).

The traditional performance measurement system of this perspective focuses on controlling and improving existing responsibilities. Also, concentrates on creating value and contributing to the company´s growth

through all the organizational process. Each organization has a unique set of processes for creating value to customers and producing management results.

(4) Learning and Growth Perspective – This perspective states that to achieve positive outcomes, the organization´s measuring process should be dynamic. Factors such as the market, climate, technology, clients, and employees regularly lead to changes in the type of information use to evaluate performance. Hence, this perspective explains the following: How the company will continue to learn and improve? The focus of this perspective is on the future as opposed to the current practices. This perspective adds the dynamic part to the BSC framework, which is to periodically measure the strategies through each of the four perspectives of the Balanced Scorecard. In the particular case of HP, the human resource is recognized as the most important driver to learn and improve the organizational processes. Therefore, measures evaluate the human resource of the company, where the investment is on personnel´s skills and capabilities. Moreover, the goal is also to enhance organizational procedures by motivating and empowering the workforce (Mohamed 2003).

This perspective establishes objectives and measures to drive organizational learning and growth. Moreover, the objectives selected in the other perspectives of the BSC identify what aspects the company must

excel to achieve the ideal performance. Nevertheless, one problem is that usually management is evaluated through short-term financial performance, and this prevents managers to invest on people´s capabilities, systems, and organizational processes for a long term. The critical enablers of the learning and growth perspective are employee: capabilities, motivation, empowerment, and alignment.

2.7. The BSC in the Construction Industry – Previous Works

2.7.1. Scorecard Approach to Benchmarking Organizational Safety Culture in Construction

This work promotes the adoption of a BSC tool to assess organizational safety culture in construction and the basis of the BSC is the company´s safety policy. In addition, this work states that construction companies agree that controlling the physical aspects and technical hazards are not the only method to reduce accidents (Mohamed 2003). Also, companies lack the insight to establish effective performance measures to achieve a comprehensive management system. To achieve an acceptable safety performance, a robust management system that incorporates metrics to monitor the performance is essential. The purpose of the BSC is to integrate all interests of key stakeholders (i.e., owners, customers, employees) through the four perspectives and asses and measure the safety culture of the organization. The tool is used to give a holistic and value-based report as opposed to only accident statistics of construction sites.

To support the potential value of the BSC a survey is conducted. This included the participation of project managers whom stated that tangible and intangible benefits are gained by the implementation of the tool. The survey findings demonstrated that industry interests are in the internal process and learning and growth perspectives. This work concludes that the BSC from a practical standpoint is a proven management framework, also, the participation of the industry members was key to identify the best measurements of the strategic objectives selected under the four perspectives (Mohamed 2003).

2.8. Limitations of Previous Works and Gaps-in-Knowledge

The HP information collected from state agencies and companies concentrates on recommendations to secure the construction site during the different phases before a hurricane. Furthermore, the current practice of monitoring and control the preventive activities is conducted by observations and filling check-sheets. Thus, the use of an organizational approach which measures performance by the use of indicators is nonexistent.

Additionally, previous works that have applied the balanced scorecard approach to analyze safety, management, or disaster preparedness problems; do not emphasize the cause-effect relationships between the goals and performance measures comprised per perspective of the BSC. Similarly, more detail should be added on how the scorecard components were determined and understand what objectives influence more the performance of safety culture in an organization.

Likewise, lagging indicators to measure performance are mainly use, and leading indicators should be highlighted as performance enablers for the long term of the organization.

This research, proposes a framework to increase awareness of the high importance of the resources in a construction site, and the eminent risk that this property has when is exposed to extreme wind conditions. To support the gaps-in-knowledge regarding the limited consideration of hurricanes impacts to construction sites, this work intends to assess the contractor´s current practices which also are not considered in previous works. Also, this research takes into account the issues that construction companies have and how this can influence or impact the organizations overall performance during the preparations before a storm. Thus, the focus is on the organizational processes that lead to hurricane-preparedness-scorecard goals achievement. Consequently, to measure these factors several strategic measurements are proposed under each perspective of the BSC, this is presented further in chapter three.

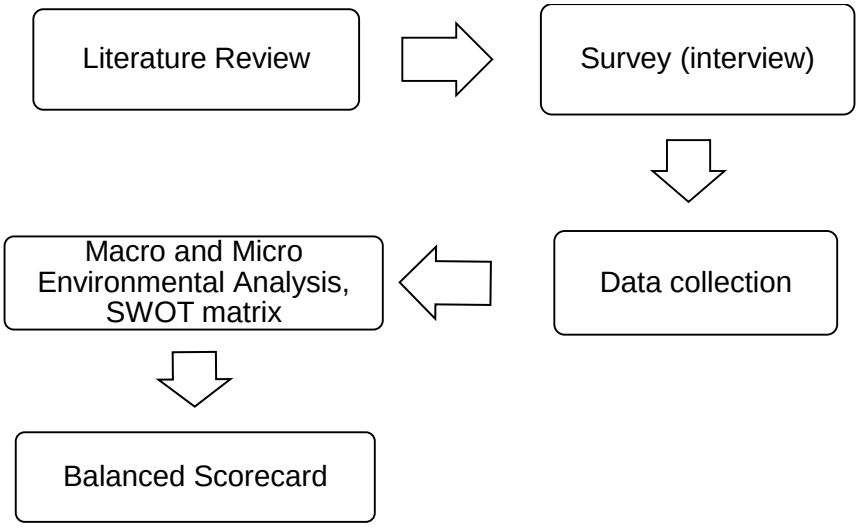
3. METHODOLOGY

In the prior section, previous works on HP and performance management tools were rigorously reviewed. Building on such information, in this section, intensive interview-surveys are conducted with key project personnel from different construction companies. This to understand current operational protocols, best practices, and issues on HP that currently the industry has. Then, the insights from the domain expert evaluations are applied for the Micro and Macro Environmental Analysis of the problems. Both analysis allow to create the HP SWOT matrix (i.e., strengths, weaknesses, opportunities, and threats) which finally delivers the strategies for the HPP assessment that are implicit in the BSC.

For further analysis, a BSC is used to recommend objectives and metrics to improve the performance of the HPP of construction companies. This is achieved in terms of the following perspectives: (1) the Internal Process Perspective, (2) the Learning & Growth Perspective, (3) the Customer Perspective, and (4) the Financial Perspective.

The BSC framework which is the outcome of this research mainly focuses on issues related to human behaviors, these are understood to be extremely influential in the organization performance. In this study, employees (e.g., workers, operators) and project partners (i.e., subcontractors) play an important role in the execution of the HPP best practices. The BSC goals and measurements for HP are further depicted in this chapter. Figure 2 depicts the overview of this research:

Figure #2: Methodology overview



3.1. Data Collection

Multiple constructions companies were invited to participate in this research and intensive survey-interviews were conducted to understand the current practices and challenges that the industry currently has.

3.1.1. Construction Companies Survey-Interview

The literature review helped to understand the problems and identify the main criteria established on the state of practice for securing construction sites. Building upon the criteria identified from the literature review and the current HPP, one structured interview form was created for industry professionals. The four perspectives of the balanced scorecard were also integrated when formulating the interview questions. The title of the eight interviewees is Senior Vice President of Project Management & Construction (one), Safety Vice-President (one), Safety

Director (two), Project Executive (one), Senior Safety Manager (one), Safety Manager (one), and Superintendent (one). Two of the interviewees work at New York and Ohio respectively and the remaining work at Miami. The interview included two sections and the questions were:

Section I:

- What is your general experience regarding severe wind conditions in a construction site?
- In your opinion, what are the important components to consider for hurricane preparedness in the construction site, and what are the best practices that the company has towards these important components?
- How do you measure these best practices and components in the construction site?
- What are the challenges and limitations on implementing these best practices?
- Regarding hurricane preparedness and the best practices, what do you think about government regulations and their effect to the construction site?
- What new approach do you think is needed on site for hurricane preparedness?

Section II:

- Regarding the construction schedule, can you mention activities classified as weather sensitive in the construction site?

- If experienced a severe wind condition, approximately, what percentage did the damages represent in the total cost of a construction project?
- Can you approximately mention what percentage of the total construction cost of a project, does the implementation cost represent?
- What do project owners think about the action plan implementation during a project?

3.2. Survey general views

The objective of this section is to gather general views of the industry professionals. The interviewees' responses helped to identify different views and recognize the following observations for HP:

3.2.1. Current practices, challenges, and limitations

All the respondents agreed that weather monitoring is an important practice that is conducted in a daily basis by the use of mobile applications or national weather forecast webpages. Also, only half of the interviewees stated that internal training of employees is imparted in their construction sites. Additionally, 75% of the respondents mentioned that in Miami the hiring of unexperienced operators and workers is a common practice. This due to the high demand of construction projects, and in relation to this, 75% of the respondents stated that organizational culture is a major issue that hinders robust preparedness plan implementation.

Based on the responses mostly workers and operators come from underdeveloped countries and a strong barrier exists to implement such preparedness plans. Furthermore, 75% of the respondents also mentioned that pre-negotiated rates of contracts are not an important factor since in practice this is always included in the contract document. Moreover, only 37.5% of the participants mentioned that the HPP is always included as part of any ownership contract. Furthermore, 37.5% of the respondents mentioned insurance companies' participation as key for the training process of employees. In contrast 12.5% of the respondents mentioned that is "always the contractors' responsibility" and that insurance companies inform of implementation practices to avoid covering high cost if damages occur. This last view could possibly be the reason why certain construction companies do not set efforts on training the personnel for HP. Then, a high level of preparedness culture is difficult to achieve without the insurance agencies support.

In regard to construction components (e.g., materials and equipment) or uninstalled elements, 62.5% of the respondents think that roofs deserve special attention. In addition, a current practice is to apply "effective weights" over the sensitive uninstalled surfaces to counteract any uplift. Likewise, another key concern is the highest level of a building under construction where the priority is to secure the structural elements, 87.5% of the participants highlighted this. Furthermore, 62.5% of the participants mentioned plywood is an important component that should be secured in construction sites. Regarding construction equipment, the majority of the respondents mentioned that tower cranes are the most dangerous under extreme wind conditions, other participants mentioned

scaffolds and hoists. In relation to construction elements, plywood sheets deserve special consideration since they easily become airborne and might impact the construction project and surroundings. The nonexistence of proper storage of construction components led the respondents to agree in a 75% that housekeeping stills a major issue to address. A list of the major factors mentioned by the participants is given in Table 1:

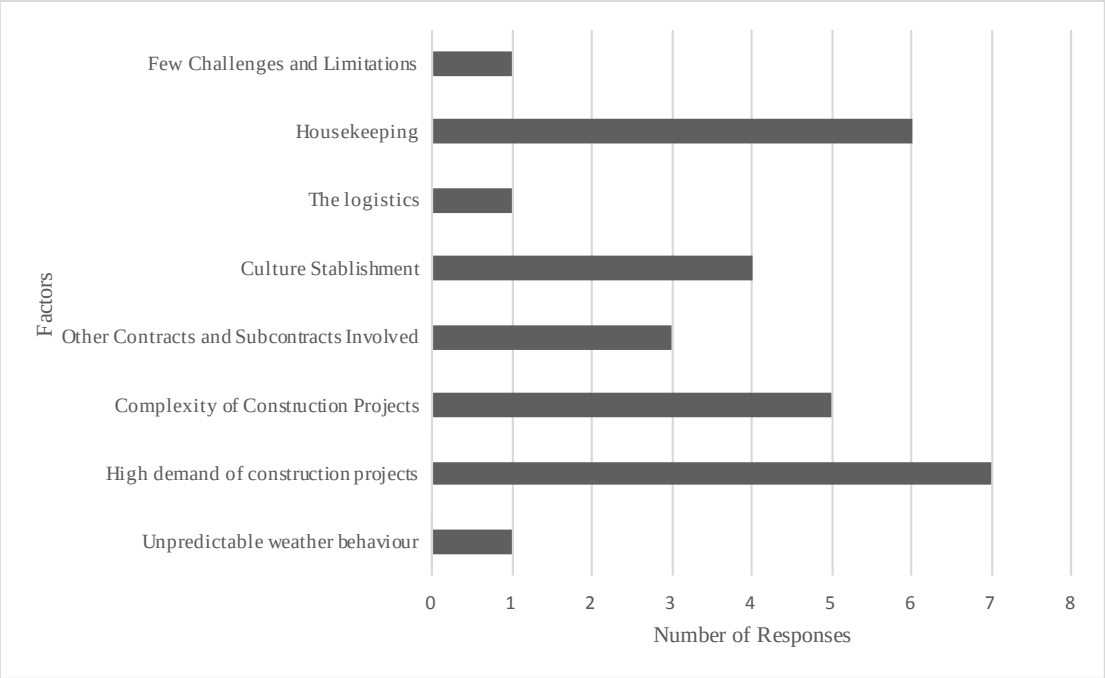
Table #1: Preparedness plan important components and current practices

Number	Factors	% of participants
1	Preparedness plan follows wind speeds criteria along with the hours in advance to apply it	75
2	Weather Monitoring	100
3	Housekeeping	75
4	Internal Trainning of employees	50
5	Hire unexperienced operators due to high demand of construction projects	75
6	Culture as a major issue to address	75
7	Contracts pre-negotiated rates	75
8	Hurricane Program included per contract	37.5
9	Insurance companies participation	37.5
	Construction Components:	
10	Plywood	62.5
11	Efficiente weights	37.5
12	Top of the Building materials and equipment	87.5
13	Roofs	62.5
14	Tower Cranes	87.5

NOTE: The % represents the number of participants that agree the component is important

There are also challenges and limitations which impede the implementation of a robust preparedness plan, according to the eight participants of the survey the following factors in chart 1 should be addressed:

Chart #1: Challenges and limitations of implementing the current preparedness plan



According to the interview results construction markets outside from Miami are more sensitive to wind conditions. For example, in New York City the pre-assessment is activated when wind speeds exceed the 25mph whereas in Miami when sustained winds reach the 35mph.

3.2.2. Measurement of the current practices

The objective of this section is to understand the level of performance of the current practices. The comments provided by the industry practitioners indicated that 87.5% measure the preparedness plan performance by the use of check-sheets. For instance, one of the participants mentioned that if the daily check-sheets indicated the assessment of any significant task, the employees or subcontractors are contacted to discuss the problem and stablish a solution. The 12.5% of the respondents mentioned the application of a task hazard analysis and a software to measure safety practices, and performance indicators have not been established. Opposed to this view, other participants think that the application of a task analysis is not useful and transcribing actions into words is a less effective practice. The majority of the respondents limit their practices' control to only observations, consequently, indicators should be applied to monitor and improve the performance of the current practices.

3.2.3. New Approach needed for hurricane preparedness

Practitioners were asked about recommendations or new approaches to improve preparedness. The majority of the respondents mentioned that in the case of Miami-Florida the new approach is to educate workers to robustly prepare and secure construction sites. Another part of the interviewees agreed that the approach is to monitor the wind speeds on a daily basis. For example, two

interviewees emphasized the importance of having “one ear and eye to the weather”.

3.2.4. Cost and schedule issues related to hurricane preparedness

The objective of this section is to gather information on the effect of severe wind conditions on cost and schedule of construction projects. All participants mentioned different examples of severe-wind-sensitive activities such as: exterior or pre-cast walls installation, roofing, glazing, activities that include formwork, lifting activities that include a tower crane operation, and any construction activity conducted at the highest levels of the structure. In total, 62.5% of the interviewees had an opinion regarding the delay in weeks that typical construction projects have due to severe wind conditions. Three (3) out of eight (8) practitioners indicated that weather sensitive activities are factored in the construction schedule, and the delay is estimated not to last longer than two weeks. Another respondent said that depending on the project duration the delay could be of six weeks. Other respondent stated that in the construction schedule the normal delay documented typically is of one week during hurricane seasons.

In general, the participants stated that the figures on the preparedness plan implementation cost are trivial and correspond to approximately 0 to 5% of the total construction project cost. Seven (7) out of eight participants stated that this percentage is actually related to the safety budget since there is not a specific percentage assigned to HP. The remaining participant said that a specific

implementation percentage could be around 0.001% of the total construction project cost.

The interviewees were also asked if they could give a percentage number of the damages cost in construction projects due to severe wind conditions. This figure was stated also to be very small as 3 to 5% of the total construction cost. Where, only one of the participants said that when hurricane Andrew impacted Florida, the complete jobsite under construction was destroyed.

Furthermore, the participants were asked as part of this section about the clients' standpoint regarding HP and the possible project delays. One (1) of the respondents mentioned that clients' attitude depends on the type of market they come from. For example, clients can come from an environment where safety is set as a priority over cost-schedule. The remaining of the interviewees said that other clients have four major components: budget, schedule, quality of work, and safety. Where, the first option is not to invest in disaster preparedness and understand the consequences for not complying with the procedures during extreme wind conditions.

3.3. Survey results and major factors identified

According to the results of the survey, one of the major challenges is the lack of alignment between the industry professionals. Preparations and views between construction practitioners vary, for example the housekeeping vision is different

from a superintendent to a safety manager. This is revealed at the end of a work day where unsecured resources of the jobsite are left without appropriate storage. The following are photographs taken in a real construction site at the end of a work day, these images belong to the SASC (Student Academic Success Center) building project located at Florida International University Modesto-Maidique Campus:

Photographs #1, 2, 3, 4, 5, 6: Unsecured construction resources such as plywood, wooden and metallic debris; envelopes with unfinished walls and openings.





The response time under extreme wind conditions varies among contractors and subcontractors. Weather uncertainty and the fact that a hurricane has not strike

Miami area in years, influences subcontractors decisions. For example, subcontractors are in general reluctant to secure the site in advance based on the high cost that preventive measures represent. Related to this, one (1) of the participants mentioned that one of the measures that subcontractors are not willing to apply is to remove scaffolding systems.

Moreover, to establish preparedness culture there is the strong need to educate construction professionals, and measure their current practices by the use of performance indicators. Thus, monitor, control, and improve the performance of the HPP.

Other major factor is the poor communication that exists from the contractors to the clients. In some cases, clients are highly wind sensitive which means they follow the regulations and standards related to HP. In other cases, clients have in mind four major components: budget, schedule, quality of work, and safety. As the majority of the respondents mentioned, it is difficult for them to find the initiative to invest in disaster preparedness in spite of being aware of the consequences.

The results of the survey identified the current practices and the issues related to HP. Construction resources such as materials and equipment are of great concerns during heavy wind conditions, nonetheless to secure these is not a major problem. The interviewees indicated that organizational errors are the most common problem to apply efficient preventive measures in a construction site. In this sense, the next section examines the issues by leveraging the macro environmental analysis (external analysis) and the micro environmental analysis

(internal). Then, the factors obtained from both analyses are used to create the strategies to construct a Balanced Scorecard that proposes strategic objectives and measurements to monitor the most relevant actions for improving the performance of the HPP.

3.4. Hurricane Preparedness in Construction Sites – Macro Environment Analysis

The Macro Environment Analysis (External Analysis) explores the trends and events that can significantly benefit or harm an organization in the future. The analysis incorporates the economic, social, cultural, demographic, environmental, political, legal, governmental, technological, and competitive aspects. According to the line of business of the company, these aspects conduct to a set of external opportunities and threats (David 2011). Moreover, opportunities and threats are understood to go beyond the control of the organization and are classified as external factors. The External Factor Evaluation Matrix (EFE) is the tool that contains the external factors that are described in detail further.

To identify the key external opportunities and threats that are affecting or might affect construction companies, the external environment is analyzed. The PEST analysis (Political, Economic, Social and Technological factors) is applied to evaluate the market where the business unit evolves. In the particular case of the HPP, the PEST analysis facilitates to understand how the efficient implementation of the preparedness plan is affected by the external environment.

3.4.1. Political Factors

The political factors determine the extent to which the government (e.g. regulatory bodies and processes, government policies) may influence and impact a certain industry or company. In the case of construction companies' HP, *safety regulations* have been selected as the most influential political factor.

The Occupational Safety and Health Administration (OSHA) under the '29 CFR 1910.38 regulation' specifies the requirements of an Emergency Action Plan. In addition, OSHA as part of a mission assignment from the Federal Emergency Management Agency (FEMA) created the Hurricane e-Matrix. This is a tool that provides standards and regulations of specific construction tasks and operations. These standards encompass general recommendations for hurricane preventive actions that should be evaluated and adapted according to the hazards associated with construction tasks. Construction companies might be impacted negatively for violating an OSHA standard where according to the Field Operations Manual the maximum penalty is around $7,000 for each violation and $70,000 for a repeated or willful violation (OSHA FOM 2015).

Similarly, the Miami Dade Municipal Code chapter 8B-11 and 8B-18 related to HP in construction sites describes the ordinances related to hoisting equipment and loose construction materials. According to the 'Chapter 8CC – Code Enforcement section 8CC-10', the civil penalty for failure to abide the procedures of the HPP is $1,000 per day, which can ascend from $2,500 to $5,000 per day.

3.4.2. Economic Factors

These factors examine the outside economic issues that might affect the construction industry. For HP, *labor turnover, number of quits, skill workforce, and seasonality/weather issues* have been selected as the influential economic factors.

According to the Job Openings and Labor Turnover report, the total separations rate (seasonally adjusted) in the construction industry is about 5.0%. This is one of the highest turnover rates in comparison to the other industry sectors (Bureau of Labor Statistics 2016). Additionally, the number of quits rate in the construction sector is 2.4% which is a significant figure compared to the other industry sectors. Construction companies are affected by these two factors that lead to significant replacement cost of employees (i.e., applicants recruit, invest in training). Furthermore, according to the survey conducted to 474 construction industry executives in 48 states, more than 61 percent stated that is very challenging to find qualified workers (Wells Fargo Construction Industry Forecast 2016). Ultimately, this fact prevents the HPP implementation since industry-specific knowledge and skills take time to master. Moreover, the turnover of qualified construction personnel can result in loss of productivity and contributes to jobsite accidents (Chih et al 2016).

In regard to seasonality or weather issues, the Atlantic hurricane season is most likely to be near-normal and forecast uncertainty influences the difficult prediction of the storms (NOAA 2016). In addition, a near-normal hurricane season prediction suggests that there might be more hurricane activities in comparison to the last

three years. Moreover, the likelihood of having named storms with sustained winds of 39 mph or higher is 70%, where a range of 10 to 16 storms are expected. Also, a range of 4 to 8 hurricane systems of 74 mph can develop and evolved into 4 major hurricanes of categories 3, 4, or 5. Another important prediction is in relation to La Niña occurrence, and as stated by NOAA's Climate Prediction Center there is a 70% chance that it evolves into more hurricane activities. However, model predictions show levels of uncertainty related to the strength of La Niña reducing the amount of impact it may cause. These factors influence weather systems behavior, where uncertainty has an effect on hurricane preparedness-related decision-makings. As a result, if the preventive measures are costly contractors might not activate the plan in advance during hurricane season.

3.4.3. Social Factors

These factors analyze the demographic and cultural aspects of the sector where construction companies develop. For HP, the following have been selected as the most influential social factors: *age distribution, attitudes toward work, job market trends, and educational issues.*

In relation to job market trends, employment in the construction industry has increased by 3.2% and 2.6% in residential and non-residential building construction respectively (U.S. Department of Labor 2016). However, the hiring of new workers is not expected to increase largely during the following periods because of the lack of suitable trained skilled personnel. For example, the *job*

openings and hires rate variation is very small for March 2015, February 2016, and March 2016; respectively these rates are 2.7, 2.9, 3.0 (Bureau of Labor Statistics 2016). Additionally, due to the shortage of qualified workers, firms have reported to increase payments and benefits to retain or recruit qualified staff.

Educational issues also play an important role. The report *2016 construction hiring and business outlook* states that firms are investing in training and development programs for current and new workers. Where a 46 percent reports to have increased their investments in training and development in 2016 compared to 2015 (AGC 2016). For HP, construction companies should invest in training efforts to have experienced workers and implement an efficient HPP. However, the only problem might be the employees' commitment since their resignation leads to negative effects and significant costs.

The remaining social factors, age distribution and attitudes toward works, are also of high importance to the construction industry. The median age of workers in the construction industry is 42 (American Community Survey 2013) and 40 percent of construction workers are "baby boomers", which predicts an exodus of experienced workers from the industry in the next decade (Welch 2010). For HP, this situation affects the plan performance since experienced construction workers are retiring and younger people with a lack of expertise are entering the organizations. Furthermore, the perception that workers have of the high risk environment in construction sites influences their decision to shift to another industry where they feel safer.

3.4.4. Technological Factors

These factors reflect how companies might be affected by the use of technology, the technological expectations that users have, and the impact that technology might have on their work. For HP is important to contemplate *the technological advancements* and *the government spending on technological research*.

Both factors are directly related to weather forecasting which is critical for timely HP. The National Oceanic and Atmospheric Administration (NOAA), the National Weather Service (NWS), and the National Hurricane Center (NHC) thanks to weather satellites can monitor temperatures inside a storm, cloud heights, rain, and wind speeds. Also, data and products from a national information database are used by other government agencies, the private sector, the public, and the global community (NOAA NWS 2010). Moreover, construction companies with such databases are able to monitor the winds behavior by the use of cellular phones and weather applications.

After the factors are selected for the PEST Analysis, these are classified into opportunities and threats. Table 2 represents this information:

Table 2: PEST Analysis Factors

Factor	Effect	Opportunity	Threat
Political	OSHA Standards and Muicipal Code regulations improvement. More specific to construction hurricane season scenario	x	
	Contractors work paralyzation due to standard violation		x
	Increment on penalties. More than $7,000 in the case of OSHA and more than $5,000 in the case of Miami Dade Municipality		x
Economic	High demand of Construction Projects (New construction starts 2016 growth of 6%)	x	
	Increase efforts on Hurricane Preparedness Plan to prevent losses	x	
	Increase of more than 5% on Employee Turnover as reason for loss on productivity and expertise		x
	Increase of more than 2.4% on the number of quits		x
	Increase on employees replacement cost (e.g., applicants recruit and invest in training)		x
	70% likelihood of named storms ocurrence and La Niña favoring hurricane activity		x
	Weather forecast uncertainty influences decision making (among contractors and subcontractors)		x
Social	0.1% increase of new construction workers hires		x
	Increase on base pay rates, incentives, and benefits to retain qualified workers or recruit them		x
	46% of the companies increase investing efforts on training and development of programs for current and new workers	x	
	Experienced workers resignation (age factor)		x
	Workers perception of the risks involved in the environment where they work		x
Technological	Government interest to spend on technological research	x	
	Government agencies available databases and infrastructure	x	
	Wind speeds monitoring by the use of computer and internet applications	x	

3.4.5. The External Factor Evaluation (EFE) Matrix

After classifying the factors into opportunities and threats, first, a weight ranging from 0 (not important) to 1 (very important) is assigned. This weight indicates the relative importance of each factor for successful HPP implementations, and in order to determine the values for each factor this research used the survey responses. The survey outcomes significantly contributed to assign more accurately the weight of each factor in the external matrix. Then, the rating is

assigned to each factor which indicates how effective construction companies' current practices and strategies are to respond to each factor, as in the case of the weight of importance the survey responses were also used to stablish the rating values. The rating used is between 1 and 4, where 4 = the response is superior, 3 = the response is above average, 2 = the response is average, and 1 = the response is poor. Finally, each factor's weight is multiplied by the rating to obtain the weighted score. The highest possible weighted score for a company is 4.0 and the lowest possible is 1.0.

In total sixteen factors among opportunities and threats are selected. Table 3 depicts the External Factor Evaluation (EFE) Matrix, and the following is the explanation of the weight and ratings assigned for each factor:

Opportunity Factors – Factor 2, *high demand of construction projects* has the highest weight of importance of 0.09. Currently, this situation obligates contractors to hire many construction workers regardless of their background, and this is why the given rating is 2. Factor 3, *increase efforts on training and development of programs for workers* has also the highest weight of importance of 0.09 since it is critical to invest efforts for robust HP implementation. The rating assigned is 2, according to the survey only 50 percent of the participants have this as a practice. Factor 6, *wind speeds monitoring* has an above average weight of 0.06. This is an important and established practice for HP, has no negative effect and construction companies perform this task on a daily basis. Therefore, the rating assigned is the highest score of 4. The remaining factors relate to government available resources

which do not represent an issue for the construction industry, this is why the importance weights assigned are lower than the average. Nevertheless, *factor 1* has a rating of 2 since although construction companies are following HP guidelines there are still opportunities for enhancement. *Factor 4* has the lowest rating value since the construction companies despite of the government efforts on research are not interested on applying research to improve HP. Finally, *factor 5* has the highest rating since the industry professional utilize all the available government data to monitor hurricanes.

Threat Factors – Factor 9, *employee turnover* has the highest weight of importance of 0.09. Currently, this represents loss on productivity and expertise. The rating is 1 due to the significant issue that construction companies have on retaining experienced construction workers. Factor 11, *increase on employee's replacement cost and base pay and benefits* has also the highest weight of importance of 0.09. The rating of this factor is 3 since the companies implement this practice to avoid project delays. Factor 13, *weather forecast uncertainty influences decision making* follows has a weight of importance of 0.08. This relates to the past storms that did not impact the project areas. The rating is 2 since in certain cases subcontractors are not willing to collaborate due to the high cost for implementing measures (e.g., scaffolds systems removal). Factor 14, *increase of new construction workers hires* has 0.07 weight of importance and the rating is 2 since to hire qualified workers is a challenge. Factor 10, *increase on number of quits* has above average weight of importance of 0.06. The rating is 2 since despite of the construction companies' efforts an employee resigning is an unpredictable and inevitable situation. Factor

15 and 16, *experienced workers' resignation and workers' perception of the work environment risks* have an above average weight of importance of 0.06. The rating in the two cases is 2 since some organizations lack efficient efforts to replace old workers and educate the employees regarding the work environment.

The total weighted score of all factors is 2.31, which is below average. This indicates that the construction companies should invest more efforts for an efficient HPP implementation.

Table 3: The External Factor Evaluation (EFE) Matrix

	Key External Factors	Weight	Rating	Weighted Score
label	**Opportunities**			
1	OSHA Standards and Municipal Code regulations regarding hurricane season	0.03	2	0.06
2	High demand of Construction Projects	0.09	2	0.18
3	Increase efforts on Hurricane Preparedness. 46% of the companies will invest efforts on training and development of programs for current and new workers	0.09	2	0.18
4	Government interest to spend on technological research	0.04	1	0.04
5	Government agencies available databases and infrastructure	0.05	4	0.2
6	Wind speeds monitoring by the use of computer and internet applications	0.06	4	0.24
	Threats			
7	Contractors work paralyzation due to standard violation	0.04	3	0.12
8	Increment on penalties. More than $7,000 in the case of OSHA and more than $5,000 in the case of Miami Dade Municipality	0.04	3	0.12
9	Increase of more than 5% on Employee Turnover (loss on productivity and expertise)	0.09	1	0.09
10	Increase of more than 2.4% on the Number of quits	0.06	2	0.12
11	Increase on employees replacement cost and base pay rates, incentives, and benefits to retain qualified workers or recruit them (e.g., applicants recruit, training)	0.09	3	0.27
12	70% of likelihood of named storms ocurrence and La Niña favoring hurricane activity	0.05	3	0.15
13	Weather forecast uncertainty (past events) influences decision making (among contractors and subcontractors)	0.08	2	0.16
14	0.1% increase of new construction workers hires	0.07	2	0.14
15	Experienced workers resignation (age factor)	0.06	2	0.12
16	Workers perception of the risks involved in the environment where they work	0.06	2	0.12
	Total	1.00		2.31

3.5. Hurricane Preparedness in Construction Sites - Micro Environment Analysis

The Micro Environment Analysis (Internal Analysis) refers to the internal factors or capabilities impacting a company (David 2011). These factors include the strengths and weaknesses (e.g., problems, constraints, uncertainties, and disadvantages) in reaching the organization's target. The strengths relate to the core competencies that the company should have for achieving goals. The weaknesses relate to the limitations that the company encounters on implementing a strategy to achieve the goals. In strategic management, the internal analysis benefits managers and employees to efficiently perform their activities and understand how these affects other areas of the company. The Internal Factor Evaluation Matrix (IFE) encapsulates major strengths and weaknesses in the functional area of the business. The challenge of this part of the methodology is that the information collection involves experienced personnel representing various organizational interests and points of view.

3.5.1. Strengths and Weaknesses Factors

In the particular case of the HPP of construction companies, the results from the survey and the contractors' HPP allowed to list the factors and classify them into strengths and weaknesses. Table 4 summarizes these factors:

Table #4: Internal Analysis Factors

label	STRENGHTS
1	Hurricane Plan included per contract with stablished pre-negotiated rates
2	A written plan which states the general administrative and on-site procedures
3	Preparedness Plan classified into phases depending on the wind speeds
4	Daily weather monitoring
5	Responsibilities under Project Executives, Managers, and Superintendents
6	Construction Companies hire instructed safety Professionals
7	Subcontractors collaboration to secure the site
8	Assessment of the hurricane preparedness plan through observations and check sheets
9	Insurance companies training support
	WEAKNESSES
10	Hiring of safety non-educated workers and operators
11	Operators/Workers replacement
12	Responsabilities in the written plan concentrated only among leadership positions and minimum emphasis on securing uninstalled materials
13	Lack of pre-assessment by the use of wind speeds monitored in a daily basis
14	Weak communication to employees/workers and lack of supervision of assigned responsibilities
15	Weak safety culture stablished among workers
16	Internal Trainning of employees
17	Poor housekeeping
18	Subcontractors reluctance to secure the site in advance due to the high cost it represents
19	Assessment is not conducted by the use of a tool that supports observations
20	Negative perception of the insurance companies role

3.5.2. The Internal Factor Evaluation (IFE) Matrix

The factors included in the internal analysis are prone to affect the construction companies' performance. After classifying the factors into strengths and weaknesses, first, the weight ranging from 0 (not important) to 1 (very important) is assigned. To assign the importance values for each weakness and strength

included in the internal matrix, the survey responses were also used. The weight indicates the relative importance of the factors for successful implementations. Similarly, rating values are assigned based on the survey outcomes. The rating is assigned to each factor which indicates whether that factor represents a major weakness (rating = 1), a minor weakness (rating = 2), a minor strength (rating = 3), or a major strength (rating = 4). Finally, each factor's weight is multiplied by the rating to obtain the weighted score. The highest possible weighted score for a company is 4.0 and the lowest possible is 1.0. Therefore, if the total weighted score is below 2.5 this means that the company is internally weak (David 2011).

The process is similar to the EFE Matrix explained in the previous section. The following represents the explanation of the weights and ratings assigned per factor:

Strengths Factors – Factor 5, *Responsibilities under key personnel* (e.g., Project Executives, Managers, and Superintendents) has the highest weight of importance of 0.08, all tasks of the preparedness plan are under the direction of such proficient industry professionals. Factor 9, *Insurance companies training support* has a weight of importance of 0.07, the training sessions these institutions provide to contractors' could improve their knowledge. Factor 4, *Daily weather monitoring* has an above average weight of importance of 0.06, this is a practice that contractors implement on a daily basis and is of extreme importance to activate a robust HPP. Regarding the remaining factors, these are required components of the HPP to support the logistics. Therefore, these factors are assigned a lower than average

weight. In relation to the ratings, factors 4 and 9 represent a major strength (rating = 4) and the other factors a minor strength (rating = 3).

Weaknesses Factors – Factor 10, *Hiring of safety non-educated workers and operators* has the highest rate of importance of 0.09 and is a situation that significantly affects construction companies. Factor 11, *responsibilities in the written plan concentrated only among leadership positions and minimum emphasis on securing uninstalled materials* has a weight of importance of 0.08, responsibilities should also be assigned to other employees to efficiently monitor the implementation. Factor 13, *Weak safety culture established* among workers has also a high weight of importance of 0.08, currently interrupts the HPP implementations, the problem is having employees of different backgrounds joining the construction industry. Factor 12, *Weak communication to employees/workers and lack of supervision of assigned responsibilities* has 0.07 of weight of importance. According to the survey not all safety managers are aware of the employees'/workers performance. Factor 15, *Poor housekeeping* has an above average weight of importance of 0.06, currently this is critical at construction sites which results into weak communication, lack of supervision, and weak safety culture. Factor 17, *Assessment is not conducted by the use of a tool that supports observations* weight is also 0.06, apart from observations the construction companies do not have other assessment tool to monitor the preparedness plans. The remaining factors have lower weight of importance, however, they represent findings of the survey to be address. In relation to the ratings, factors 10 to 17

represent a major weakness (rating = 1) and factor 18 indicates a minor weakness (rating = 2).

The total weighted score of all factors is 2.03 which is below average (2.5). This indicates that the construction companies are week internally. Therefore, the organizations should invest more efforts for an efficient HPP. Table 5 depicts the IFE Matrix and the strengths and weaknesses selected:

Table #5: The Internal Factor Evaluation (IFE) Matrix

	Key Internal Factors	Weight	Rating	Weighted Score
label	**Strengths**			
1	Hurricane Plan included per contract with established pre-negotiated rates	0.02	3	0.06
2	A written plan which states the general administrative and on-site procedures	0.04	3	0.12
3	Preparedness Plan classified into phases depending on the wind speeds	0.04	3	0.12
4	Daily weather monitoring	0.06	4	0.24
5	Responsibilities under key personnel	0.08	3	0.24
6	Construction Companies hire instructed safety Professionals	0.03	3	0.09
7	Subcontractors collaboration to secure the site	0.05	3	0.15
8	Assessment of the hurricane preparedness plan through observations and check sheets	0.05	3	0.15
9	Insurance companies training support	0.07	4	0.28
	Weaknesses			
10	Hiring of safety non-educated workers and operators	0.09	1	0.09
11	Responsibilities in the written plan concentrated only among leadership positions and minimum emphasis on securing uninstalled materials	0.08	1	0.08
12	Weak communication to employees/workers and lack of supervision of assigned responsibilities	0.07	1	0.07
13	Weak safety culture stablished among workers	0.08	1	0.08
14	Internal Training of employees	0.05	1	0.05
15	Poor housekeeping	0.06	1	0.06
16	Subcontractors reluctance to secure the site in advance due to the high cost it represents	0.05	1	0.05
17	Assessment is not conducted by the use of a tool that supports observations	0.06	1	0.06
18	Negative perception of the insurance companies role	0.02	2	0.04
	Total	1.00		2.03

3.6. The Internal and External Matrix

After the Internal and External Analysis is finished, the next step is to combine the factors contained in the EFE and IFE matrices and based on these formulate strategies to improve HP. With the internal and external matrices, the strategy-formulation technique used to identify, evaluate, and select the strategies for the BSC is the Strengths-Weaknesses-Opportunities-Threats (SWOT) Matrix. The SWOT matrix is known as a matching tool and the approach is to develop four types of strategies: Strengths-Opportunities Strategies (SO), Weaknesses-Opportunities Strategies (WO), Strengths-Threats Strategies (ST), and Weaknesses-Threats Strategies (WT).

SO Strategies - The basis is that the internal strengths of the company are used to take advantage of the external opportunities of the environment (David 2011). For example, matching more than two strengths and weaknesses is used to create a strategy; for this, the strengths and weaknesses are related or complement each other. For example, table 6 strategy SO2 “Use the wind speeds values that are daily observed” is created matching strengths S3 and S4, and opportunities O5 and O6. Where, there is the opportunity that the government agencies have available databases and infrastructure related to winds monitoring, and also technologies assist in the monitoring of winds behavior. Thus, construction companies are able to establish a framework that utilizes the daily wind speed observations and improves the management of resources in construction sites.

WO Strategies – The intend is to improve the internal weaknesses that the company has by taking advantage of the external opportunities. Nevertheless, a company´s internal weaknesses can prevent from exploiting key external opportunities (David 2011). For example, in table 6, strategy WO6 “Conduct training for all workers and operators” is created matching weaknesses W1 and W4, and opportunities O2 and O3. In this regard, externally there is the opportunity of high demand of construction projects, however, the construction companies have developed weaknesses on hiring non-educated workers. As a result the companies have a weak safety culture, nevertheless, there exists the opportunity to increase the efforts on HP. For example, according to this year statistics, 46% of the construction companies will invest efforts on training and development of programs for current and new construction workers (AGC 2016). This is the opportunity that can help to minimize the weaknesses that the companies are currently facing. Thus, the industry should invest more on specific training programs under the lines of heavy wind preparedness.

ST Strategies – The base is on the strengths that the company has to avoid or reduce the impact of external threats (David 2011). For example, in table 6 strategy ST4 “Assess subcontractor's preparedness” is created matching strength S7 and threat T7. By instance, when subcontractors intend to collaborate to secure construction sites (opportunity) the weather forecast uncertainty influences their decision-makings. If subcontractors are not certain of a hurricane event they do not respond in advance, and apply precautions to the last minute.

WT Strategies – These are constructed by reducing the internal weakness and avoiding the external threats. A company facing numerous external threats and internal weaknesses may indeed be in a precarious position (David 2011). For example, table 6 strategy WT9 “Reduce employee turnover and replacement costs” is created matching weakness W1 and threats T3 and T5. Therefore, the weakness of hiring non-educated workers should be reduced with strategical efforts to prevent the increase on employee turnover and replacement cost.

The following table contains all the strategies created with the strengths (S), weaknesses (W), opportunities (O), and threats (T):

Table #6: SWOT Matrix

SWOT MATRIX OF THE HURRICANE PREPAREDNESSES PLANS OF CONSTRUCTION COMPANIES		
	STRENGHTS	**WEAKNESSES**
	1 Hurricane Plan included per contract with established pre-negotiated rates	1 Hiring of safety non-educated workers and operators
	2 A written plan which states the general administrative and on-site procedures	2 Responsibilities in the written plan concentrated only among leadership positions and minimum emphasis on securing uninstalled materials
	3 Preparedness Plan classified into phases depending on the wind speeds	3 Weak communication to employees/workers and lack of supervision of assigned responsibilities
	4 Daily weather monitoring	4 Weak safety culture stablished among workers
	5 Responsibilities under preparedness plan leaders	5 Internal Training of employees
	6 Construction Companies hire instructed safety Professionals	6 Poor housekeeping
	7 Subcontractors collaboration to secure the site	7 Subcontractors reluctance to secure the site in advance due to the high cost it represents
	8 Assessment of the hurricane preparedness plan through observations and check sheets	8 Assessment is not conducted by the use of a tool that supports observations
	9 Insurance companies training support	9 Negative perception of the insurance companies role
OPPORTUNITIES	**SO Strategies**	**WO Strategies**
1 OSHA Standards and Municipal Code regulations regarding hurricane season	1. Review and Improve the Hurricane Preparedness Plan Document (S2, O1, O2)	6. Conduct training for all workers/operators (W1, W4, O2, O3)
2 High demand of Construction Projects	2. Use the wind speeds values that are daily observed (S3, S4, O5, O6)	7. Measure employee's performance after each training session (O3, W3, W4, W5)
3 Increase efforts on Hurricane Preparedness. 46% of the companies will invest efforts on training and development of programs for current and new workers	3. Create a training program per project (S6, S9, O3)	8. Reduce or eliminate unnecessary loose materials or debris (W6, O3)
4 Government interest to spend on technological research		
5 Government agencies available databases and infrastructure		
6 Wind speeds monitoring by the use of computer and internet applications		
THREATS	**ST Strategies**	**WT Strategies**
1 Contractors work paralyzation due to standard violation		
2 Increment on penalties. More than $7,000 in the case of OSHA and more than $5,000 in the case of Miami Dade Municipality	4. Assess subcontractor's preparedness (S7, T7)	9. Reduce employee turnover and replacement costs (W1, T3, T5)
3 Increase of more than 5% on Employee Turnover (loss on productivity and expertise)	5. Measure preparedness plan leaders performance (S5, S6, T4, T5)	10. Reduce the number of employees' quits (W3, T4, T10)
4 Increase of more than 2.4% on the Number of quits		11. Measure employee satisfaction (W4, W5, T8)
5 Increase on employees replacement cost and base pay rates, incentives, and benefits to retain qualified workers or recruit them (e.g., applicants recruit, training)		12. Reduce possible paralyzation and penalties by assessing the most sensitive components registered on the check sheets (W8, T1, T2)
6 70% of likelihood of named storms ocurrence and La Niña favoring hurricane activity		13. Introduce per project as part of the training program a special topic(s) that insurance companies can impart (W9, T1, T2)
7 Weather forecast uncertainty (past events) influences decision making (between contractors and subcontractors)		
8 0.1% increase of new construction workers hires		
9 Experienced workers resignation (age factor)		
10 Workers perception of the risks involved in the environment where they work		

3.7. Hurricane Preparedness Balanced Scorecard

After identifying the strategies that construction companies should implement for efficient HP, the next step is to establish strategic objectives. Then, strategic measurements are assigned to each objective to monitor performance.

Strategies

These are selected from the external and internal analysis matrix (SWOT). The strategies are first analyzed under the management perspective and then the cause-and-effect relationships are established to link this perspective to the other perspectives of the BSC. These strategies help on the development of the strategic objectives of all the different perspectives of the BSC, for each objective is possible to combine more than one strategy as presented further.

The strategies on table 6 are used to create the scorecard, in total there are thirteen (13) strategies and the following numbers (e.g., SO1, SO2) are used further to identify the link that exists between the strategies of the SWOT matrix and the Objectives of the BSC: SO1 Review and Improve the HP Plan Document, SO2 Use the wind speeds values that are daily observed, SO3 Create a training program per project, ST4 Assess subcontractor's preparedness, ST5 Measure the leader’s performance, WO6 Conduct training for all workers/operators, WO7 Measure employee's performance after each training session, WO8 Reduce or eliminate unnecessary loose materials or debris, WT9 Reduce employee turnover and replacement costs, WT10 Reduce the number of employees quits, WT11 Measure employee satisfaction, WT2 Reduce possible penalties by assessing the most sensitive components registered on the check sheets, WT13 Introduce as part of the training program the participation of insurance companies.

3.7.1. Management Perspective

The focus of this perspective is on the HP policy and the management commitment and leadership. By the use of this elements in the BSC, the results reflect project control activities (e.g., directing, leading, planning, and coordinating) with specific measures to accomplish the objective of the HPP. To do that, once the organization´s business strategy is identified, objectives are selected, and then the objectives are translated into measures or indicators.

Strategic Objectives

This corresponds to the *Hurricane Preparedness Plan Policy*. The HPP policy states that the organizations must take precautions prior a hurricane. This, to minimize property damages, accidents, and production downtime for the construction projects. The HPP policy is subdivided into strategic objectives to select the indicators, also, the strategies constructed with the SWOT tool are taken into account for the strategic objectives of the BSC. The SWOT strategies used to construct the objectives are mentioned in parenthesis next to each objective, and the number assigned in the previous section is used to identify them (e.g., ST5, SO1).

The strategic objectives proposed for the management perspective are: *Lead by example (ST5), Contribute to the HPP operating performance (ST5, SO1), Contribute to the improvement of the HPP (SO1, WT13).*

Strategic measurements

These are the indicators to measure the strategic objectives, these measurements are classified into leading and lagging indicators. The lagging indicators represent traditional performance measures; these are normally used by the organizations to assess the status of the company or project. The leading indicators represent proactive measures that reflect the effectiveness of the management activities. In this research, both type of indicators are used for the HP BSC.

The strategic measurements of this perspective are: *Extent of management involvement to improve preparedness, Monitoring of each perspective of the BSC, Number of hurricane preparedness initiatives*:

- To measure *Extent of management involvement to improve preparedness*, construction companies can develop questionnaires or conduct group interviews. This captures the behavioral, situational, and psychological aspects to understand the level of involvement of each member in the organization that has an active role in the decision-makings (Mohamed 2003).
- To measure *Monitoring of each perspective of the BSC,* the preparedness team should simply monitor the goals and indicators that are proposed for the other BSC perspectives. These are presented further in this section.
- To measure the *Number of hurricane preparedness initiatives*, companies would have to register the number of initiatives that are proposed during each meeting to review the hurricane plans.

The measurements of this part were adapted from the previous work of Mohamed (2003) that applied the BSC for safety assessment.

3.7.2. Customer Perspective

This perspective of the BSC embraces two types of customers: the clients and the employees. Regarding HP, clients are classified as highly-wind-sensitive or not; this depends on their backgrounds and the construction markets they come from. For example, there are cities where the hurricane standards are more conservative making their markets more sensitive towards preparedness. As a result, clients support all procedures that are required to secure construction sites even if these causes schedule overruns. In contrast to this, clients might be reluctant to stop the daily progress of the construction works in spite of the potential risk that heavy wind conditions represent. Also, in the construction industry clients tend to base their project preferences along dimensions like: price, time, quality, functionality, and service; where preparedness or safety procedures have poor importance. Moreover, the significance is to understand how these customers perceive the role of preparedness and the efforts of the organization to achieve HP culture.

The customer perspective is used to assess how employees or clients perceive HP on construction sites. Thus, it is important to set indicators of the extent to which the members are actually implementing the BSC. This, indicates if additional opportunities exist for improving the preparedness plan performance and enhancing preparedness culture in the organizations (Mohamed 2003).

Consequently, descriptive measures are selected to capture clients as well as workers' opinions regarding the preparations that the company should implement for HP. The measures should reflect the customers understanding or awareness of HP, also, how they perceive the work environment and the attitude they have towards their organizational obligations.

Strategic Objectives

The strategies from the SWOT analysis are also used to stablish the strategic objectives of this perspective. The SWOT strategies used to construct the objectives are mentioned in parenthesis next to each objective, and the number assigned in the previous section is used to identify them (i.e., SO1). The strategic objectives proposed for this research are: *Increase customer (clients and employees) understanding of the on-site preparations and efforts in case of heavy winds (SO1), Foment employee satisfaction and Reinforce workforce morale (WT9, WT10, WT11), Exceed Clients expectations (SO1).*

Strategic measurements

After determining the strategic objectives of this perspective, the metrics to measure them are constructed. Therefore, to measure the objectives of the customer perspective the following indicators are proposed: *Extent of meetings, Extent of rewarding employees with excellent performance, Response time under heavy wind events:*

- The *extent of meetings* indicator helps to improve the level of communication between the construction companies and the customers. This is measured by the *number of meetings* with customers. For example, the construction companies would have to establish monthly meetings with clients to inform of the status of the project and the changes in schedule due to HP. Likewise, remind to employees HP guidelines in a daily basis for example as part of the pre-shift planning meetings before starting the construction works.
- To measure the *Extent of rewarding employees with excellent performance*, the construction companies can simply establish a program where the best employees are rewarded monthly.
- The *Response time under heavy wind events* is measured by how in advance a construction company prepares for a storm. For example, the companies can register the time they spend to secure the construction site and test it during an emergency drill. Currently, construction companies in Miami do not have hurricane drills and the practice of such could significantly help them to improve their best practices. Also, the response time not necessarily needs to start 72 hours in advance of the event (as the HPP suggests) but could be activated before this time for a better use of the resources.

3.7.3. Internal Process Perspective (Operational)

The core component of management systems are rules and procedures. Moreover, a safety management system program is based upon the statement that safety is a management responsibility and a line function (Mohamed 2003). However, the success of preparedness programs depends on the ability of site management to assure that rules and policies are followed during daily work operations. Therefore, this perspective is concerned with the efficient implementation of HP procedures in construction sites. Furthermore, the greatest strength that the BSC provides is that employees are more aware of the relation between policy, procedures and performance targets. This helps to identify opportunities for meaningful improvement on HP guidelines and as a result achieve a high level of compliance of the hurricane program.

Strategic Objectives

The objectives proposed for this research under this perspective mainly focus on the core issue that currently construction companies have: the employees' performance and the subcontractors' compliance with HP. The SWOT strategies are also used to construct the objectives and are mentioned in parenthesis next to each objective, and the number assigned in the previous section is used as well to identify them. Then, the following objectives are proposed to improve the performance: *Reduce number of incidents (WO8, WT12), Implement an efficient follow-up system (ST5, WO7, WT11, SO1), Emphasize subcontractor´s awareness (ST4), Establish a suitable working environment with all working*

relationships (WT9, WT10, WT11), Improve housekeeping (SO2, WO8, WT12), Implement hurricane preparedness drills (SO3, ST4, ST5, WO6, WO7, WO8).

Strategic measurements

To measure each objective the following metrics are proposed: *Level of incidents, Remedial actions ratio, Subcontractors attitude towards preparedness, Workers degree of satisfaction, Level of unnecessary construction components on site, Level of mistakes per hurricane preparedness drill:*

- The *Level of incidents*, contractors could account for the number of incidents per month.
- For the *Remedial actions ratio*, construction companies should register the number of recommendations made per HP meeting and compare it with the number of the actions successfully implemented. This ratio could be measured in a monthly basis:

$$Remedial\ actions = \frac{Implemented\ actions}{Recommended\ actions}$$

  This indicator was adapted from Mohamed (2003) that applied the BSC for safety assessment.

- *Subcontractor's attitude towards preparedness* is measured by the compliance to HP. This group decision is based on the weather uncertainty and the cost of the preventive measure. For example, the level of weather uncertainty is high if they base their decision on the fact that a hurricane

has not hit Miami for approximately ten years. Consequently, subcontractors are not willing to apply costly preventive solutions.

- The measure *Workers degree of satisfaction* the construction companies can conduct satisfaction surveys to get inform of their attitude towards the company. For this, a scale could be fixed where 1 is very dissatisfied and 10 very satisfied. Another way of recognizing if workers are satisfied is by looking to the employees' turnover and level of performance indicators which are explained further.
- For the *Level of unnecessary construction components on site,* the construction companies can monitor this per week by accounting for the number of equipment, materials, and debris that should be storage properly during hurricane season (specially the days of high winds).
- For the *Level of mistakes per hurricane preparedness drill* is necessary to implement a drill system for hurricanes. To measure the mistakes, companies would have to simply register the number of omissions of the hurricane drill (activities not accomplished during the time of this exercise).

3.7.4. Learning and Growth Perspective

This perspective relates to a periodic review of the BSC, for this the objectives and metrics should reflect core elements of the BSC that should be monitored during a timeframe and contribute to the problems identification. Additionally, the BSC reviews suggest the modification of the scorecard by including only the pending

goals. Likewise, the BSC strategy, goals, and measures should always have the focus on learning and improvement identifying the gaps between the goals and existing performance.

Strategic Objectives

Similarly to the other perspectives, the SWOT strategies are used to construct the objectives and are mentioned in parenthesis next to each objective, the number assigned in the previous section is used to identify them. Moreover, the key to achieve performance is represented by organizational culture, employees' attitude, and education. Therefore, in order to enhance the human capital of the organization the following objectives are proposed: *Provide adequate training to workers (SO3, WO6, WT13), Upgrade employees' competencies (WO7), Empower workforce (WT9, WT10).*

Strategic measurements

To measure the goals of this perspective the following metrics are selected: *Workers competency, Employee Performance, Extent of workforce proactive involvement to improve the level of preparedness:*

- *Workers competency* is measured by the following ratio:

$$Workers\ competency = \frac{Number\ of\ hours\ of\ training\ received}{Number\ of\ ideal\ hours\ of\ training}$$

  Where, the number of ideal hours of training should be of 30 hours according to OSHA, and the minimum is 10 hours.

- The *Employee Performance* is measured by the impact that employee overtime and workers' competency have on their performance. The overtime refers to the additional hours that a worker works during the week, in general if a worker works more than 40 hours per week the performance tends to get lower.
- For the *Extent of workforce proactive involvement to improve the level of preparedness* factors such as employee turnover, employee rewards, and employee overtime are taken into account. These factors are used to calculate the workforce morale which reflects the workers proactive involvement. By instance, the *workforce morale* and the *employee turnover* could be calculated with the following formulas:

$$Workforce\ morale = 100\% - Overtime\% - Turnover\% + Rewards$$

$$Employee\ turnover = \frac{Number\ of\ employees\ separations\ per\ month}{Average\ number\ of\ employees\ per\ month} \times 100$$

3.7.5. Hurricane Preparedness Balanced Scorecard Summary Table

The following table contains the strategic objectives and strategic measurements proposed for this research, both are classified under each perspective:

Table #7: Hurricane Preparedness BSC

Perspective	Strategic Objectives	Strategic Measurements
Management	Lead by example	Extent of management involvement to improve preparedness
	Contribute to the HPP operating performance	Monitoring of each perspective of the BSC
	Contribute to the improvement of the HPP	Number of hurricane preparedness initiatives
Customer	Increase customer understanding of the on-site preparations and efforts in case of heavy winds	Extent of meetings
	Foment employee satisfaction and Reinforce workforce morale	Extent of rewarding employees with excellent performance
	Exceed Clients expectations	Response time under heavy wind events
Internal Process	Reduce number of incidents	Level of incidents
	Implement an efficient follow-up system	Remedial actions ratio
	Emphasize subcontractor´s awareness	Subcontractors attitude towards preparedness
	Establish a suitable working environment with all working relationships	Workers degree of satisfaction
	Improve housekeeping	Level of unnecessary construction components on site
	Implement hurricane preparedness drills	Level of mistakes per hurricane preparedness drill
Learning and Growth	Provide adequate training to workers	Workers competency
	Upgrade employees competencies	Employee Performance
	Empower workforce	Extent of workforce proactive involvement to improve the level of preparedness

4. RESULTS AND DISCUSSION

4.1. Survey main aspects

The survey interviews incorporated safety managers, superintendents, and project executives, where a total of eight views described current practices and issues regarding HP. Furthermore, the survey questions included the following topics: (1) Current practices, challenges, and limitations; (2) Measurement of the current practices; (3) New approach needed for hurricane preparedness; and (4) Cost and schedule issues related to hurricane preparedness.

The study revealed that construction markets out from Florida are more sensitive to severe wind conditions. For example, according to the HPP of a construction

company from New York City, the pre-assessment starts when wind speeds exceed the 25mph. In contrast, the HPP of Miami construction companies is activated when sustained winds reach the 35mph. Since the last severe storm was hurricane Sandy which principally affected NYC, standards and regulations are stricter in areas away from Florida. Thus, the lessons learned encouraged this industry professionals to develop more HP guidelines and enrich their safety-preparedness culture. Consequently, these guidelines are currently used as a base by construction companies located in Florida.

The survey responses also revealed that clients of the construction industry have different perceptions regarding HP. Depending on the clients' background, they are more aware of the importance of implementing a HPP and understand the possible changes in the construction schedule. Moreover, for the type of clients that are unaware of the importance of the hurricane practices, is necessary to extent the efforts of communicating them the plan and the status of the project during hurricane season.

Additionally, the survey results indicated that one of the major factors to improve is housekeeping, this basically is present due to the lack of alignment among industry professionals. Hurricane preparations and views among the players of a construction company vary, for example, between superintendents to safety managers. This is noted at the end of a work day in the construction site, where unsecured resources are not properly storage and could get up-lifted causing damages. To reduce or eliminate this problem, construction companies should

establish a specific monitoring system where they are able to monitor the amount of unsafe resources per week and correct the issue.

Another view of the survey showed that the application of preventive measures in advance of the storm could be challenging among subcontractors. For instance, since weather is uncertain and in the past hurricanes did not strike Miami, subcontractors are in general reluctant to secure the site because of the high cost that it may represent. In reference to this, one of the survey participants mentioned that this normally happens when subcontractors have to remove scaffolding systems. To overcome this problem, contractors should enforce the construction site protection in advance by the use of clauses in the contract documents, also another alternative is to extent the efforts towards subcontractors' compliance.

Finally, the survey results demonstrated that the main problem to not implement a correct HPP is related to the employees of the organization. Where, contractors in Miami-Florida have the tendency to hire non-educated workers due to the high demand of projects. Therefore, the interviewees indicated that there is the high requirement to educate the personnel, specially workers and operators. Their lack of experience and diversity of backgrounds reflect an immense challenge to accomplish the objectives of a HP culture. Nevertheless, to improve this situation construction companies should invest more efforts on training the personnel. A major problem is that previous studies have revealed that in Florida immigrant construction workers are treated different. For example, they are not receiving complete training due to their language barrier (Nissen 2007). Thus, construction

industry should work hard to address this inconvenient and set special efforts to nurture the education and enhance the competency of this segment of construction employees.

4.2. Balanced Scorecard main aspects

The BSC proposed in this research reflects the strategic objectives recommended to improve the performance of a HPP. These objectives were constructed after analyzing the strength, weaknesses, opportunities, and threats that might affect the hurricane plan. After the SWOT analysis all main criteria is synthesized into thirteen strategies which lead finally to the strategic objectives.

The HP BSC recommends in total fifteen (15) strategic objectives which are classified under the perspectives of the scorecard (i.e., management, customer, internal process, learning and growth). Also, fifteen (15) metrics are recommended to monitor and control the performance of each strategic objective of the HPP (the objectives and metrics are depicted in table # 7).

In addition, the BSC framework contains top-down strategies and represent a chain of cause and effect relationships. Therefore, the proposed BSC should be viewed as a set of hypotheses about cause and effect relationships that affect the performance of the HPP. A top-down driven strategy method means that the top level perspective affects the following perspectives. For example, if the management perspective objectives are not achieved, the customer perspective objectives are not either. To understand this better, the four perspectives are discussed and summarized:

The Management Perspective involves the management active participation which contributes to the HPP operations' improvement. To increase the extent of the management involvement, this research highly recommends that the organizations stablish a follow up system of the activities and goals related to HP. Also, to monitor the managers' involvement surveys or meetings could be conducted, by this the construction company can assure that management is complying with the plan. Other measurements of the scorecard under this perspective require that management contributes with initiatives to the plan and monitor their performance. Thus, management should add value to the organization's HPP by offering initiatives during every meeting related to this topic. For example, these initiatives could be part of the scorecard's strategic objectives and metrics. Then, to enhance the HP practices and improve the BSC outcomes managers should monitor the performance of the other perspectives in the scorecard.

The Customer Perspective incorporates the customer understating of HP which benefits the hurricane decision-makings. The BSC has as customer's clients and employees, and through the objectives of this perspective the aim is to increase the understanding of the HPP. Thus, this research recommends that companies schedule strategic meetings to discuss this special topic. Also, is imperative to foment employees' satisfaction to improve their performance. Then, this research suggests that the companies define a monthly reward system for the employees that best comply with all the plan's requirements. As a result, employees' performance is enhanced and by responding in advance to heavy wind events the company exceeds client expectations of protecting the construction site.

The Internal Process perspective comprises recommended activities to implement an efficient HPP. The goals of this perspective consist of reducing the incidents that occur in a monthly basis (omission of a preventive measure). To measure the level of incidents of the HPP this research recommends the construction companies to establish a scale that represents the level of incidents (i.e., high, medium, low). This simple method, helps companies to recognize the activities for more supervision and improvement. Also, by recognizing the level of incidents the companies can decide a “target level” of incidents to achieve periodically. Moreover, to follow-up the execution of HP initiatives, this research recommends that construction companies stablish a “remedial actions ratio”. This ratio compares the implemented remedial actions with the total proposed actions. The remedial actions correspond to the HP initiatives or corrective actions that the team suggests as part of the improvements of the plan. Another key component of this perspective relates to enhance subcontractor’s awareness and to measure their attitude towards preparedness. Thus, a recommendation is that companies increase the subcontractors’ understanding and enforce hurricane preparations within the legal contract. By the determination of rigorous penalties subcontractors unquestionably comply and their performance is improved. The following recommendation under this perspective relates to establish a suitable environment for workers. For example, by measuring the employees’ satisfaction via survey. This helps the organizations to recognize the employees’ attitudes at work and prevent a high turnover rate by understanding the employees’ preferences. The last objectives of this perspective recommends housekeeping improvement and to

put in practice hurricane emergency drills. For this, the construction site should be monitor in a weekly basis regarding all the materials and equipment that are not storage properly. Once this is identified, a scale to measure the levels (i.e., high, medium, low) of unnecessary components in the construction site shall be created. This allows industry professionals to monitor and control housekeeping with a scale basis, also, the method creates housekeeping consciousness among all employees by showing the results of this goal of the BSC. Finally, to test the feasibility of the hurricane emergency drill a recommendation is to create also a scale to measure the level of mistakes per drill.

The Learning and Growth Perspective highlights the core aspects to enhance the overall performance of the BSC, the purpose of this perspective is to periodically monitor goals (strategic measurements). The objectives of this level of the scorecard are related to the employees training enhancement which ultimately delivers competent workers. For example, a recommendation is to monitor the number of hours of training received which intends to fill the gap related to workers' education that in Florida deserves special attention. Furthermore, to know if the level of training is delivering progress among all the construction workers then competencies should be upgraded. This could be identified by measuring the workers' performance and the effect of doing overtime. This metric can serve to compare workers' performance and improve the weekly work schedule to reduce unnecessary additional work hours. Finally, the workforce empowerment is of extreme importance to increase the employees' involvement in the HPP. For this the workforce morale should be strengthen by reducing the amount of overtime

which is proved to impact productivity, also as mentioned before, rewards shall be implemented. Another recommended factor to measure the employees' involvement is the employee turnover which ultimately affects the workforce morale. The reason of this cause-effect relationship is that to terminate the working relation creates a negative work environment that influences all workers' performance towards HP.

5. CONCLUSION

5.1. Summary

HP current state of practice principally focuses on the compilation of total damages and design codes improvements in pro of a resilient construction site. However, uninstalled and unsecured elements in the case of engineering structures and resources are highly vulnerable components regarding extreme wind conditions such as hurricanes. In general, inclement wind driven damages cause interruption to construction sites planned schedules which lead to delay, and as a result negatively affect construction projects efficiency. Additionally, the lack of alignment of an organization team is the principle cause which interrupts an efficient HPP execution. To contribute to this situation, the HP current practices and main issues of the construction companies were evaluated through a comprehensive study that included interview surveys and a BSC approach.

The construction companies that were the subjects of this study are organizations strongly positioned in the construction market, however, for HP there is room for improvement and creating certain capabilities among employees. Moreover, once

the survey was conducted and the current practices and main issues were identified, this research applied a PEST analysis and an Internal-External Environmental Analysis. Both tools utilized information from the survey and literature regarding the construction industry´s political, economic, social, and technological factors that influence HP. After this analysis is done, strategies are constructed in order to recommend the construction companies particular areas of improvement.

This research recommends strategic goals and metrics to monitor and accomplish a high performance which eventually improves the safety-hurricane-preparedness culture in the construction organizations. From a practical standpoint, the BSC is a recognized management framework which identifies links between objectives and measurements. This tool allows construction companies to assign responsibilities and targets per each perspective to monitor and control the progress of the scorecard. This framework also offers a company to proactively manage HP and asses the problem apart from only using observations and check-sheets. Moreover, the information of the BSC adds value to HP by delivering relevant and aligned information available to all stakeholders. For this, construction companies should select a handful of objectives and measures that represent the HP policy without having information overload.

A fundamental premise of the BSC is that each perspective is reviewed on a regular basis to monitor performance and improve it, this is why targets and responsibilities could be set as part of the framework. Furthermore, the BSC

method can influence employees by their actions which eventually encourages behavioral changes to achieve optimum performance and a zero-incidents preparedness culture.

5.2. Limitations and Future Studies

Limitations

The constraint of information under the HP topic is a limitation of this research. Therefore, the analysis was constructed only with the responses of interview-surveys of certain construction companies. This situation leads to the standpoints of a specific group of practitioners and does not mean that the practices and problems revealed by them could be generalized to all construction companies. Consequently, a limitation is that the recommendations stated in this work might not apply to all industry cases.

Another limitation of this study is the reduced interest of construction companies regarding the HP topic. Thus, it was challenging to obtain specific information related to cost-schedule issues and as a result this was not included as part of the BSC analysis. Likewise, information related to performance indicators was also difficult to obtain since the companies do not apply this as metrics to measure their performance. Thus, certain indicators proposed in the BSC were adapted from previous works and others created without a solid base.

Future studies

Future studies of HP in construction sites include the validation of the performance indicators proposed in the BSC of this research. This should be achieved by reviewing the BSC metrics with the industry professionals and improve the input information used to calculate each performance indicator. Thus, the strategic measurements propose as part of this research framework can result into stronger tools to measure the performance level of construction companies.

Finally, to increase the understanding of the cause-effect relationships of the BSC components an Agent Based Simulation (ABS) could be constructed. This may include a model capable of absorbing the BSC framework and data that should be provided by the industry professionals to increase the accuracy of the method. The simulation framework could be applied to model all the attributes of HP and by this test the viability of performance indicators. Likewise, the application of an Agent-Based model enables practitioners to analyze complex systems such as the construction site environment. Where, the benefit of constructing this kind of model is that the influence of human behaviors is also included as part of the analysis which compliments the BSC framework.

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