

Impact of Hurricanes on Small Construction Business and Their Recovery

by
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A thesis submitted to the Department of Construction Management,
College of Technology
in partial fulfillment of the requirements for the degree of

Master of Science
in Construction Management

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University of Houston
May 2022

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DEDICATION

I would like to dedicate this thesis to my parents, and my husband, Dr. Sabyasachi Prakash, without whose support this thesis would not have been possible.

ACKNOWLEDGEMENTS

I would like to acknowledge my professors, the department, and my fellow colleagues for their constant support throughout my research.

ABSTRACT

About 3 to 5 hurricanes on average impact the U.S. every year. Hurricane Katrina and Hurricane Harvey, each accounted for over a hundred billion dollars in damages. Small businesses face numerous challenges during major disasters. A better understanding of disaster recovery performance of small businesses is critical to enhance their resilience and thus protect our economy and employment for future recurring disasters.

This study characterizes the impact of Hurricane Harvey on small construction business with respect to damages to their facilities, supply and demand, and business operation. Their recovery performance – whether businesses fully recovered or not, how long it took, funding sources, challenges, resilience practice, and lessons learned – is closely examined through an interview study in addition to a previously conducted survey study. Small construction businesses tend to use work volume as the primary measure of whether their business is fully recovered or not.

The full recovery time for construction industry is nearly 6 months like other industries. In addition, investing in resilience significantly shorten the recovery time, evidenced by the mean recovery time of 6 months and 9 months for resilience investing business and non-investing ones respectively. There is a wide range of efforts observed in preparing their business against hurricanes (i.e., disaster preparedness) and reviving their operation quicker to the pre-disaster level (i.e., business resilience). This paper also highlights observations of the unique challenges faced by women-owned construction businesses.

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1 INTRODUCTION

1.1 Background

Federal Emergency Management Agency (FEMA) defines a natural disaster as any occasion such as hurricane, tornado, storm, flood, earthquake, landslide, mudslide, snowstorm, fire, or other natural or manmade catastrophes that warrants actions to save lives and to protect property, public health, and safety (Goss, 1996).

There are two types of disaster declaration made according to FEMA: major disaster declaration and emergency declaration (Goss, 1996). These declarations determine the amount of assistance that is offered. A major disaster declaration provides a wide range of federal assistance programs for individuals, businesses, and public entities, including funds for both emergency and permanent improvement work. Meanwhile, the emergency declaration programs support emergency services such as protection of lives, property, public health, and safety or to lessen or avert the treat of a catastrophic threat of a catastrophe occurred in U.S. The amount of such assistance provided for a single entity can be up to \$5 million.

This study focuses on the impact of major hurricanes on small construction business. On an average, 3 to 5 hurricanes impact the U.S. every year. In the last 30 years of the top two costliest hurricanes, each have accrued over a hundred billion dollars in damages. This research studies one of the above-mentioned hurricanes, Hurricane Harvey, which hit Texas coast accruing over \$125 billion in damages.

SBA's size standards define whether a business entity is small and, thus, eligible for Government programs and preferences reserved for “small business” concerns (SBA). Size standards have been established for types of economic activity, or industry, generally under the North American Industry Classification System (NAICS). Special interest is on small residential

and commercial construction companies due to critical roles they play in post disaster rebuilding. SBA size standard for construction of buildings (Subsector 236) and Heavy and Civil Engineering Construction (Subsector 237) is \$36.5 million and for Subsector 238—Specialty Trade Contractors is \$15 million (SBA, 2019). Trade associations and SBDCs will play an important role by helping with refinement of survey questions and connecting the research team to target correspondents. The data will not only detail broad impact of Hurricane Harvey on local economies but also shed light on common and unique financial challenges it posed especially on small businesses.

Alesch et. al. (2001) report that small businesses consistently provide more than one-half of the total employment in the United States and is responsible for creating an even greater number of new jobs. Small businesses face a lot of challenges when a major disaster impacts their business. Small businesses are often those that are impacted most and have little capacity to recover after disasters (Asgary, 2010).

According to FEMA (Scarinci, 2016), almost 40% of the small businesses in U.S never reopen after suffering a major disaster. Some businesses must close for days or even weeks with consequent loss of revenue that may never be recovered. Only a few businesses can shut down for that length of time and are expected to survive after reopening. Therefore, studying the recovery efforts of small businesses after a major disaster is highly significant. This study characterizes the impact of Hurricane Harvey on small construction businesses, e.g., damages to physical properties and facilities, business operation, market condition and competition, resource supplies, and their recovery performance, e.g., whether businesses fully recovered or not, how long it took, challenges, and lessons learned.

In addition, according to a study by Morrow and Enarson (1996) on Hurricane Andrew, women-owned businesses faced more challenges than their men counterparts. These businesses

were found to recover slower in the case of Hurricane Katrina too (Marshall et al., 2015). Therefore, there is also a need to study unique issues faced by women-owned businesses regarding disaster resilience and challenges.

1.2 Problem Statement

The effect of a major hurricane on recovery efforts of small construction businesses has not been studied in detail to the author's knowledge. The focus of this study is to assess the impact of a major hurricane, Hurricane Harvey, on small construction businesses and their recovery.

To understand the impact of major hurricanes and the recovery process for small construction businesses, the following research questions will be investigated.

1. What is the impact of hurricanes on small construction business (in terms of damages to facility, business operation, employment etc.) and characteristics of their recovery? Were businesses fully recovered or not, if they did, how long did it take?
2. What are the challenges faced by small construction businesses during their recovery after hurricanes, key factors affecting the disaster recovery efforts and lessons learned?
3. Literature review suggests that not all small construction businesses recover in the same manner. Women-owned businesses have been seen to recover slower in case of Hurricane Katrina. Therefore, there is a need to investigate this topic further in our research. What are unique challenges women-owned businesses facing with than their male counterparts?

1.3 Objectives

The objective of this research is to better understand the characteristics of small business and their recovery process to clarify challenges and precautionary steps that may be taken to prepare for further disasters, minimizing damages and improving resilience.

The specific objectives of this research include the following:

1. To provide a better understanding of hurricane impact on small construction business regarding facility damage, business and financial operation, supply, and demand.
2. To identify key factors affecting business recovery and lessons learned for faster recovery.
3. To characterize the unique challenges faced by women-owned businesses.

This study also addresses some of the practical issues for industry practitioners. Impacts of hurricane on small construction businesses can be of many types. Small business recovery efforts can be most likely characterized by indicators reported by individual business owners. Some of common areas of study are physical damage to building facilities, job sites, and transportation, as well as power lines and electricity supply. Hurricanes have a significantly negative impact on transportation and inventory which affects the supply of raw materials. Owing to damages suffered by the whole community, new projects and contracts might get delayed in lieu of emergency work in critical infrastructure for public welfare (e.g. – hospitals, bridges, roadways and power lines etc.). Small construction businesses feel cash crunch when these projects are delayed as they planned their finances around these upcoming projects. Federal and local governments offer financial assistance to struggling small businesses. Awareness about these loan application processes is not readily available. The timing of the disbursement of financial assistance also plays

a critical role in the time to recovery. Education, opportunity, and exposure are some of the issues that women owned business are likely to face during disaster recovery.

1.4 Thesis Organization

This report is organized into five chapters, including this introduction chapter. Chapter 2 explores previous related research work in the form of literature review. It first discusses about the impact of natural disasters such as hurricanes, earthquake, and flood on small businesses and their damages. A part of the literature review also summarizes various disaster recovery related issues faced by women-owned business owners. Chapter 3 outlines the methodology adopted in this study, including survey study, interview study, and data analysis. Results from the survey data analysis and interviews are presented in Chapter 4. The conclusion and future research will be discussed in Chapter 5.

2 LITERATURE REVIEW

A lot of research work has been conducted regarding the impact of hurricanes on small businesses in the United States. Corey and Deitch (2011) studied factors affecting business recovery immediately after Hurricane Katrina. Many business owners returned to find multiple types of damages to their structures, inventory, and equipment. They assessed the types of damages and found that businesses experiencing more physical damages would be less likely to recover from the disaster.

Corey and Deitch (2011) studied factors affecting business recovery 6-8 months after Hurricane Katrina in New Orleans, Louisiana in 2005. Many business owners found multiple types of damages such as infrastructure and power, equipment, and flooding of facilities. The study found that businesses experiencing more severe storm damages and post-disaster problems complicated by population dislocation, loss of customer base, and staffing issues negatively affect post-disaster recovery and business performance. Collier et al. (2020) studied small business financing outcomes about one year after Hurricane Harvey based on their credit reports and a detailed survey and found that the flooding increased credit delinquencies and recovery financing is commonly based on personal resources and earnings. In the case of Hurricane Katrina, older business was found to have a lower likelihood of achieving recovery six years after the hurricane compared with younger businesses, as older business appeared to have lost more during and after the hurricane (Hiramatsu and Marshall, 2018). Meanwhile, over 50% of the surveyed businesses had not recovered one year after the disaster struck, while over 9% reported permanent closure.

Several studies of disaster impact on businesses did not find significant association between disaster preparation and business recovery (e.g., Chang and Falit-Baiamonte, 2003; Dahlhamer and Reshaur, 1996; Webb et al., 2002). Nonetheless, emergency plans were

perceived to be valuable in improving communication with employees for disaster preparedness despite that the degree to which emergency plans were executed and the effectiveness of such plans were not verified. Kropp et al. (2007) recommended that organizations need more than just a “disaster preparedness plan”, but also a “business continuity plan” which covers protections for vital data and resources. One of the biggest risks is that businesses become complacent with their emergency preparedness plan and do not update it periodically (Scheier, 2004). As evidence, a survey found that 36% of all businesses with an emergency preparedness plan prior to Hurricane Sandy had never tested it, and that percentage was lowered to 27% after Sandy (Scarinci, 2016). Small businesses were also found to be less likely to engage in disaster risk reduction efforts through business continuity planning (Zhang et al., 2009). Future research should use more objective ways of measuring emergency plan effectiveness and examine the potentially confounding effects of post-disaster performance (Corey and Deitch, 2011).

The role of government disaster relief programs, especially the U.S. Small Business Administration (SBA) loans has been studied. The immediate government response to Hurricane Katrina at all levels, including local, state and federal, has generally been viewed as uncoordinated (Olejarski and Garnett, 2010). For example, some complained of workers being poached away from rebuilding sites that impeded the recovery progress (Runyan, 2006). They report that the process of obtaining disaster loans was complicated and the issuance of funds delayed. As a result, most businesses had to rely on private loans for recovery. Moreover, small businesses are less likely to afford comprehensive insurance coverage (Yoshida and Deyle, 2005; Zhang et al., 2009). Limited funding compounded with the lack of insurance protection contributed to the delay in small business recovery.

The role of employees and business owners towards recovery has also been investigated. Hiramatsu et al. (2018) described a business as resilient if its post-disaster performance such as revenue are better off compared to its pre-disaster level. Small business recovery is likely to be characterized by indicators unique to each business owners. Boin and McConnell (2007) found that most of the common barriers to organizational resilience is associated with the adaptive behavior of citizens, front-line workers, and middle managers. People tend to speculate that catastrophic infrastructure breakdowns would not happen to them. In addition, owning versus renting of business premises is another important predictor of a business's strategies toward disaster preparedness and recovery (Dahlhamer and Tierney, 1996). Specifically, owning a business property provides more access to financial resources than renting, thanks to business property equity. Similarly, Dahlhamer and D'Souza (1995) argued that one of the main hindrances for motivating small businesses for disaster preparedness is the fact that many do not own rather rent their business facilities. Property-owning small businesses tend to be more engaged in disaster preparedness efforts than their property-leasing counterparts, and this observation was confirmed by other researchers as well (e.g., Turner et al., 2020).

Corey et. al. (2011) reported that, among the performance of the various industry sectors towards recovery, construction businesses reported the most increases in business opportunities post-Katrina. Hiramatsu and Marshall (2018) reported that the construction and manufacturing industries realized gains from post disaster reconstruction after Hurricane Katrina. Dahlhamar and Tierney (1998) reported that the largest proportion of recovered businesses after the Northridge earthquake was found in the manufacturing and construction sector. Core et. al. (2011) report that the performance of the various industry sectors was not surprising to find that construction businesses reported the most increases in business volume post-Katrina. That has been a consistent

finding in previous disaster research, as construction businesses are directly needed for recovery, and so obviously will see greater demand for their services.

Further, gender plays an important role on disaster recovery performance, e.g., women-owned business was found to be less likely to receive private or federal disaster funds (Nigg et al., 1990). The general literature on small businesses also suggests that female business owners often faced greater challenges than their male counterparts in establishing and maintaining businesses, and that woman-owned businesses had higher failure rates and lower profit margins than those owned by men (Auster, 1991). Female owners appeared to be less successful in recovery from natural disasters when compared with male owners (Hiramatsu and Marshall, 2018). Specifically, in the case of Hurricane Andrew, according to Morrow and Enarson (1996), women-owned business faced more challenges than other businesses. Josephson and Marshall (2016) reported that women-owned businesses are more likely to apply SBA loans, although they are also more likely to receive loans of a smaller amount. Sydnor et al. (2017) found that certain businesses (e.g., younger and smaller) and their owners (e.g., women and minorities) in the areas affected by Hurricane Katrina were more likely to close within five years after reopening their doors. Also, during Hurricane Katrina, owners who are female, minority or veteran had higher chances of business closure as their approach towards their business is different from that of male business owners (Marshall et al., 2015). Their businesses were least likely to experience complete recovery at least partially because their limited recovery financing sources and a low utilization rate of federal aids. Marshal (2016) found that education may play an important role to increase loan application and success rates for women-owned businesses. In addition to capital accessibility, Fothergill (1996) also indicated that women-owned businesses tended to have a lower level of savings, insurance coverage, wages, and mobility.

In summary, most of the published literature focuses on small businesses in general. Small construction businesses face some unique challenges and opportunities comparing with businesses in other sectors. The effect of natural disasters such as hurricanes on small construction businesses and their recovery has not been studied systematically in terms of the disaster impact on business infrastructure, supply and demand, and disaster preparedness and recovery strategies. Considering the critical role that construction plays post-disaster, a closer look of small construction businesses recovery performance will not only provide the guidance much needed for the construction industry, but also support a faster recovery of the impacted region through a more efficient reconstruction effort. In addition, the unique challenges faced by women-owned small construction businesses after a major hurricane have not been studied in the past.

3 METHODOLOGY

This research conducted an online survey and an interview study to examine the impact of Hurricane Harvey and the recovery of small construction businesses.

Data from a previous survey study conducted by our research team on Hurricane Harvey was utilized to analyze the recovery of small construction businesses. Details about the survey study are documented in Keeler et al. (2022). Impact of hurricanes can be of many types as described in the literature review. To investigate each type of damage and their impact on recovery, many of the referred authors collected data from the affected businesses using surveys. We followed a similar path for the collection of data for our research. Over 600 small business owners and senior management from a wide range of industry sectors participated in the survey, and 93 are from the construction industry and the rest are from non-construction industries classified as healthcare, manufacturing, finance, transportation, hospitality and food, administrative and information services.

Descriptive statistical analysis is applied to the survey data to evaluate the impact of the hurricane on small construction business, their recovery status (fully recovered or not), length of recovery time, effect of disaster preparedness and financing on recovery, and understand the statistical spread in the data to evaluate the relative importance of recovery factors over others.

For hypothesis testing to confirm if there are statistically significant variations of different classification (e.g., construction vs non-construction, investment in resiliency vs non-investment in resiliency, etc.), chi-square tests of independence test were performed for relevant datasets.

The purpose of this test is to statistically prove if the two variables in the test are same or different. The null hypothesis H_0 is defined as – “variables are same i.e., they come from the same

statistical distribution”. Hence, if the null hypothesis is true, it implies that the statistical distribution (parameters - mean and std. deviation) of variables are not different. The alternate hypothesis H1 is defined as – “variables are not same i.e., they come from the different statistical distribution”. Hence, if the alternate hypothesis is true, it implies that the statistical distribution (parameters - mean and std. deviation) of variables are different. The confidence level selected for the chi-square tests is 95% ($\alpha = 0.05$). Microsoft excel was used for evaluating the chi-square tests.

In addition to the above survey study, to develop insights of business behaviors and practices, decision rationale, and lessons learned, we also conducted an in-depth interview study with 12 small business owners through individual 45-minute online meetings. The interviewees were recruited via an invitation email to various construction business owners to participate in the survey and share their Hurricane Harvey experience. Some of the survey participants expressed an interest for the follow-up interview. Furthermore, the research team reached out to local industry connections and business associations and recruited additional participants, such as member companies from the National Association of Minority Contractors (NAMC) and the American Subcontractors Association (ASA). The first section of interview questions is about the interviewees’ business overview, how they define full disaster recovery, and whether their business recovered, if they did, how much time they took to recover from Hurricane Harvey. The second part of the interview focuses on physical damages to the businesses’ infrastructure, followed by the impact on business operations from a supply, demand, and contact administration perspective. The third section inquiries about the funding sources for disaster recovery, such as a government grants, private loans and fund, and interviewees’ experience of obtaining funds. The last part of the interview discusses about resilience practices in protecting their businesses, lessons learned, and future improvements. As appropriate, women-owned businesses were also asked

about their opinion about unique challenges that they faced with in the recovery process. The interview form including the list of questions can be found in Appendix A. The above interview study received the approval from Institutional Review Boards (IRBs) at the University of Houston.

Among the twelve interview businesses, all had major operations in greater Houston area, which was impacted by Hurricane Harvey, while a few also offices or projects in other Texas locations or adjacent states. Four of them operate primarily as general contractors or developers and the rest nine classify them as subcontractors, home remodeling, and consulting services. Majority of them or eight worked on commercial sectors (including public work and institutional building) and rest or four involved in the residential construction sector (including remodeling). Their typical revenue ranges between \$50k to \$35 million prior to Hurricane Harvey in 2017.

4 DATA ANALYSIS AND DISCUSSION

This chapter summarizes data analysis of the survey data, and the interview study results. Where appropriate, descriptive statistics and observations obtained from the survey study are also presented, e.g., overall recovery performance (i.e., recovery status and duration), how construction compares with other non-construction industry, and recovery performance regarding disaster preparedness. Relevant literature corroborating the inferences made from the interviews and survey are also presented.

4.1 Recovery and Timing

Anticipating different individual perceptions, we started the interview on interviewees' definition of "full" recovery, e.g., by comparing with self before vs. after-hurricane in terms of financial stability, business operation, or facility and asset, or relative to their competitors. Consistently, participants defined full recovery by comparing with their own performance instead of that of their competitors as to whether their business has restored to the pre-disaster level. This makes sense as the performance of competitors are largely unknown, and there is no timely post-disaster benchmarking index available to inform relative recovery performance of a business. Development of such benchmarks can have practical values, but it is outside the work scope of the current research and should be further investigated in future research. Furthermore, all participants used work volume as the primary measure of recovery, followed by other secondary indicators such as resumption of field operations, project bidding efforts; restoration of business property; and normal material and labor supply.

In the literature, recovery or resiliency is often viewed as the recovery of "revenue" to its pre-disaster level (e.g., Hiramatsu et al. 2018). However, for construction businesses, there is a delay between services and payments, including progress payment (mostly with a 30–45-day

delay), retainage, and possible claims and disputes that stretch over a long project period (ranging from months to over years). Thus, work volume serves as a leading indicator of business recovery, while revenue or cash flow is considered as a lagging indicator by the participants.

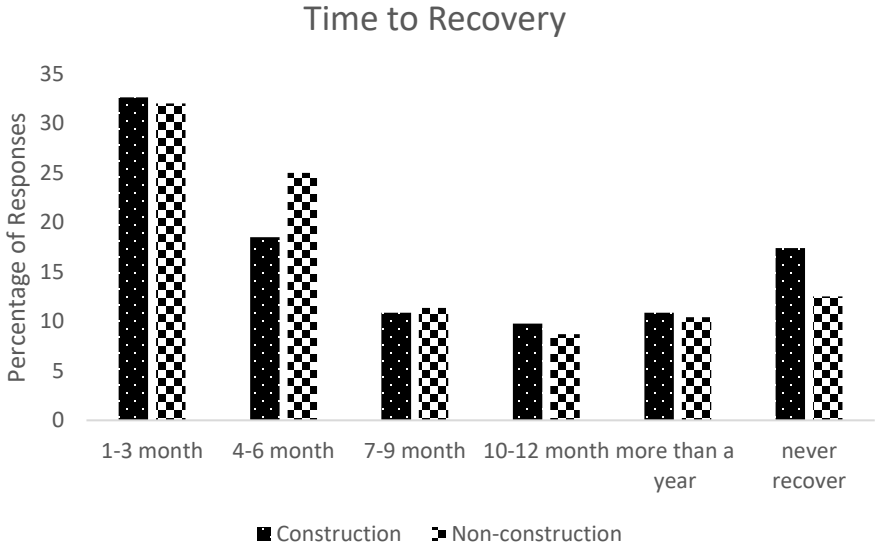


Figure 4.1 Time to recovery for construction and non-construction sectors.

The time it took for small businesses to recover varied greatly as shown in Figure 4.1 based on the survey data. The time ranges from 1-3 months to over a year (or never recover), with a mean recovery time of 7 months for construction and non-construction sectors combined. There to evaluate if there is no significant difference between the two industry categories in term of recovery time, a chi-square test is conducted. Null hypothesis H0 – “there is no statistical difference between the construction and non-construction industry with regards to time to recovery”. Alternate hypothesis H1 - “there is a significant statistical difference between the construction and non-construction industry with regards to time to recovery”. The actual data set is shown in Table 4.1. The expected chi square values are shown in

Actual	Time to recovery							Total
	1	2	3	4	5	6		
Construction	30	17	10	9	10	16	92	
Non-construction	169	132	60	46	55	66	528	
Total	199	149	70	55	65	82	620	

Table 4.2. The chi-squared value was found to be $0.708 > 0.05$, hence the null hypothesis H_0 is not rejected. Thus, we can reasonably infer that construction businesses perform similarly regarding the recovery time as the rest of businesses.

Table 4.1 Actual recovery time for construction & non-construction.

Table 4.2 Expected recovery time recovery for construction & non-construction from chi-square test.

Expected	Time to recovery							Total
	1	2	3	4	5	6		
Construction	30	22	10	8	10	12	92	
Non-construction	169	127	60	47	55	70	528	

	Total	199	149	70	55	65	82	620
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The interview shows similar results: one was effectively not recovered (despite returned to the market several years after), two are still not fully recovered to pre-hurricane level, and the rest recovered as quick as after 1 month to over 15 months, with an average about 5 months. This is all based on the recovery of work volume standpoint. Businesses did report that construction work was resumed after about 1-2 weeks in most of the cases after regaining the access to job sites, despite prolonged material and labor supply challenges. Some businesses shifted their focus from typical construction work to emergency repair work (e.g., cleaning debris or tearing down drywalls) to improve their cash flow, thus were able to continue their business right after the hurricane.

As can be observed in both the survey and interview results, recovery and time of recovery varied significantly and subject to many potential influencing factors. Construction business is a unique when compared with other industry sectors such as manufacturing and transportation. Construction is a project-based industry that is labor-, material-, equipment-, and capital-intensive with services conducted on the client site, mostly outdoor, over a long time period with prolonged progress payment schedule, thus subjects to higher business risks, e.g., schedule delay, cost overrun, safety accidents, contractual disputes, and poor cash flow. Based on our survey and interview study, factors that affect post-Harvey recovery performance can be summarized into two major categories: hurricane damages to a business’s property and to the public infrastructure that the business operated in, and the consequential impact on business operations from a supply and demand perspective. They are discussed in the two sections below.

4.2 Hurricane Damages to Business Property and Infrastructure

The built environment, including both business properties and the infrastructure, is critical for normal business operation. To understand the effect of major disasters and mitigate their effects, we need to characterize the type of physical damage that follows a major disaster. Damages to offices, equipment, warehouses, as well as infrastructure and network interruptions or outages related to power, water, internet, and transportation were associated with slower recovery (e.g., Keeler et al., 2022). Dahlhamer et al. (1999), focusing on the Northridge and the Loma Prieta earthquakes, found that water service disruption can have a significant negative impact on businesses. Specifically, they found that even very brief disruptions of water service could yield major losses for a business, while similar short-term losses of communication services had little effect. Damages to business property can be highly dependent on individual businesses, their geographic location and, to some degree, their preparedness prior to a disaster.

For construction business interviewed, the property damage can be found in home offices, job sites, and warehouse/on-site storage. Except one case of complete loss of the business office due to several-feet of flooding, the damage was either not present or relatively minor (e.g., broken windows). The home office condition was perceived to have a controllable impact on business operation because real construction work is done on the job site and in the project (mobile) offices.

According to the survey, more than three quarters of small businesses were able to recover rather quickly (within 6 months) if their buildings were not damaged. Unique to construction business is job site condition which has a direct impact on whether work and cash flow can resume. Like the office situation, many job sites were inaccessible due to temporary transportation problems, some experienced flooding and related loss of materials, which shut down the normal work until the sites were dewatered and cleaned. Disaster preparedness efforts, such as having

water pumps and back-up power generators, helped for a quick repair of damaged properties and job sites.

With regards to infrastructure, Figure 4.2 shows a distribution of types of infrastructure interruption suffered by business based on the survey result. Around 90% of the survey participants reported issues related to transportation, followed by internet outage, power and water outage, regardless of business sectors. The interview results indicate that construction work was completely shut down for 1-2 weeks, mainly due to transportation-related road closure, followed by flooded job site and worker accessibility issues (i.e., incapable to return to work due to their own home damages).

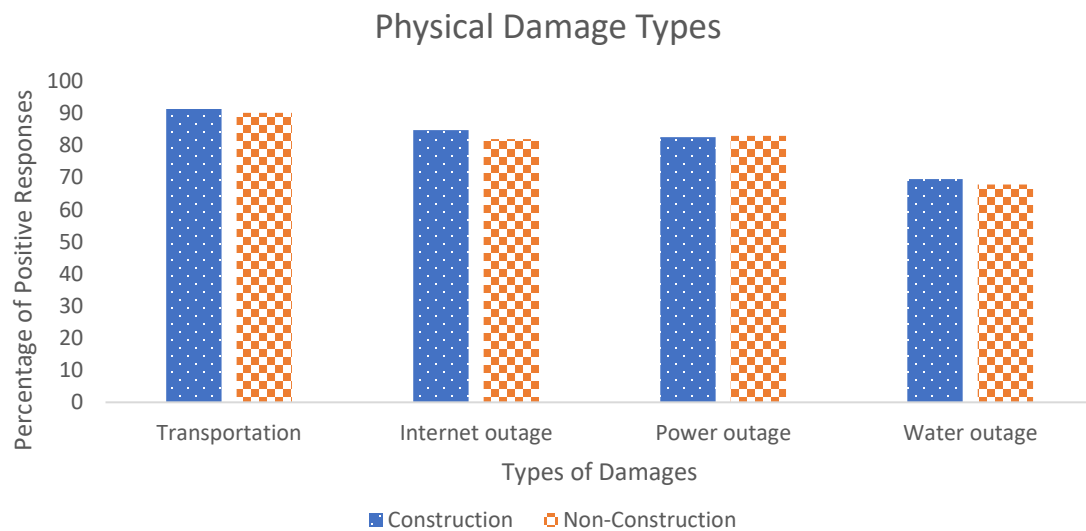


Figure 4.2 Types of damage faced by the survey participants during hurricane Harvey.

A summary Damage – Impact matrix plot of the types of damages and their associated impact on recovery as observed in the interview reports has been shown in Figure 4.3. Job site flooding / inaccessibility was reported to be high impact factor as well as high damage. The physical damage to office / trailer were reported as minor damage with minimal impact on

recovery. Although, electrical issues and internet outage were not ranked high in damage, they had a bigger impact on road to recovery. Interview respondents reported that any damage to office such as flooding or roof related damage, although significant, had lower impact on recovery as most of the work is done on the job site.

Impact on operation	High	Minor damage to job office and site inventory	Job site flooding/inaccessible Business office flooding
	Low	Minor damage to business office	Water leak at business office
		Minor	Major
Types of Damage			

Figure 4.3 Impact matrix plot of different types of damages.

4.3 Impact on businesses operations

This section discusses the impact of Hurricane Harvey on construction business operation from market demand, resource supply, and contract administration perspectives, including whether such impact is short or long term.

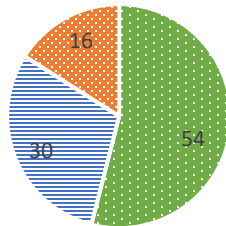
4.3.1 Impact on Market Demand

Market demand can be characterized by surge or loss of new or existing projects and clients, deviation of normal project or work types, and change of market competitions. A comparison of business activity changes for construction industry on a quarter over quarter basis

pre- and post-Harvey suggests that more than half (54%) of construction businesses reported higher business activity, but later, that decreased to about 44% a year after Harvey along with more businesses reporting decreasing activity or no change (Figure 4.4). In comparison, 51% non-construction business reported an increase on a quarter over quarter basis, and that increased to 54% one year after Harvey along with fewer businesses reporting decreasing activity (Figure 4.5). This observation can be attributed to the fact that construction industry plays the pivotal role in repairing and strengthening facilities and infrastructures for a quicker recovery of businesses and communities. The construction sector experienced a sudden increase of emergency repair demands from homes, streets, to electrical systems within days and weeks after the hurricane hit. However, it is a mixed bag for the mid-term (several months out) and the long-term (a year out) (Figure 4.6). Conceptually, the disaster reconstruction can be summarized in three phases: 1) initial emergency work (e.g., stopping leaks and interior tearing out) which can be days after a disaster; 2) repair

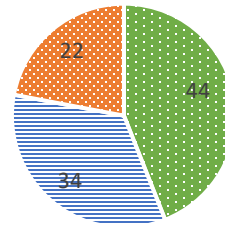
work of damaged building elements or systems by remodeling contractors; and 3) long-term restoration or enhancement effort one to several years after a disaster.

Construction - Business Activity Quarter



■ Increase ■ decrease ■ no change

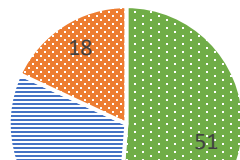
Construction - Year over Year



■ Increase ■ decrease ■ no change

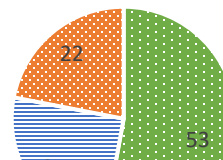
Figure 4.4 Comparison of business activity changes in construction industry on a quarter over quarter and year over year basis.

Non construction Business Activity Quarter



■ Increase ■ decrease ■ no change

Non-construction Year over Year



■ Increase ■ decrease ■ no change

Figure 4.5 Comparison of business activity changes in non-construction industry on a quarter over quarter and year over year basis.

As shown in the interviews, smaller contractors tended to adjust quickly to refocus on emergency work to meet the market demands while trying to stabilize work volume and cash flow. Meanwhile, larger, and more established contractors maintained their work scope with minimum

changes, and only did selective emergency work to help their existing clients. Active on-going projects during the hurricane were resumed despite temporary shutdown, but there were quite some upcoming or prospective project cancellations due to the interrupted client investment pattern (e.g., loss of project funding and change investment decisions). This contributed the loss of work volume for many contractors a few months after the hurricane. Other reasons led to reduced work volume were related to the loss of communication with clients and impacted capability to handle new projects due to own hurricane damage and labor and material shortage as discussed further later. An encouraging note was that contractors, especially those in the public sector, benefited from long-term recovery project efforts, including major multi-years projects funded by government and public agencies, e.g., City of Houston, flood control districts, and Army Corp of Engineers. From a market competition standpoint, there were increased competition including out-of-area contractors for emergency and remodeling work.

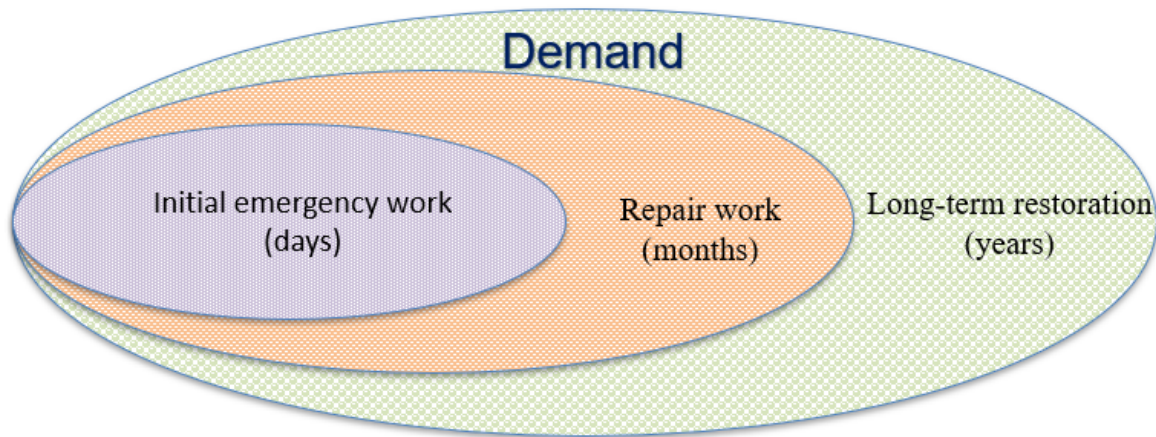


Figure 4.6 Impact of demand with time after hurricane.

4.3.2 Effect on Supply

Supply chain interruption and continuity are critical for recovery. Many businesses with no physical damage can experience significant impacts from supply chain interruptions and may be forced to close because of this indirect effect (Corey and Dietch, 2011).

Supply involves workers (including labor, crew, management staff), subcontractors/specialty service providers, materials (e.g., lumber, drywall, paint, floor covering), equipment and power tools related to primarily job sites and project offices. The biggest challenge reported by the interviewees was labor shortage a result of multiple causes, including workers whose own home were damaged by the hurricane, road closure, high craft worker turnover due to competitions, and for the similar reasons, challenges in making new hires in a tight and competitive labor market. Except few larger contractors who owned warehouse facilities and inventories, almost all contractors complained about material delivery delay and price spike for about 2 months after the hurricane. With respect to equipment, water pumps were in high demand for dewatering at offices and job sites. In two cases, the contractors also reported loss of materials and power tools due to theft.

4.3.3 Contract Administration and Cash Flow Practice

Business and contract administration cover a wide range of topics related to contractual protection against natural disasters, schedule and cost relief from clients, progress payment and cash flow issues.

The interviews confirmed that it is a common practice in standard construction contract agreements to include a force-majeure or act-of-God clause agreement to protect contractors (and owners) against events beyond their reasonable anticipation or control. However, the clause typically covers time extension of a project only, not extra cost compensation for work and schedule recovery unless change orders can be justified. Meanwhile, builder's risk insurance is a

common practice to protect work-in-progress (e.g., unfinished structure and building materials) against disastrous events such as fires, even flooding as well as business income insurance if within the coverage. In few exceptions, contractors did not use standard contract agreements and ignored any protective clause in case of disasters. Along with no or inadequate insurance coverage, they were exposed to higher risks, and led to severe financial damages during Hurricane Harvey, e.g., had to use own fund to cover repairs of damaged open trenches.

Among all business operation challenges, poor cash flow is frequently quoted as the number one cause of construction business failure. Small businesses tend to have limited financial resources and are particularly vulnerable to disaster impact due to work stoppage, loss of revenue, and further delay of progress payments.

In our interviews, businesses who could not maintain a positive cash flow either had to close their businesses or took a significant loss to maintain their business for a very slow recovery. Clients' project funding sources, e.g., public vs. home remodeling funded by insurance payment, were also perceived to have a direct impact on timely payment. Meanwhile, the interviews also showed various strategies which contractors had used to protect their cash flow and keep them afloat during challenging times, which will be further discussed in the resilience practice section.

4.4 Financing

Finance plays an important role in the process of recovery. Previous authors have found that there are 3 major types of funding sources in case of disaster recovery i.e., Owner, bank, Private source/ Investor. Recovery from a disaster takes both time and funding. Type of finance source was identified as a possible factor affecting the recovery time of the surveyed companies. The survey shows businesses obtained funding from a variety of sources, including government loan, bank, private equity, business owner financing or line of credit.

According to the results of the analysis (Figure 4.7), more than 85% of those who recovered used at least a bank as their primary funding source, while more than 80% of business owners used self-funding or funds from a business partner/investor in construction industry. We have found similar evidence in our interview studies. In our interview analysis, we found that 5 businesses rely on banks as their primary funding source, 4 businesses self-fund their businesses, and 2 businesses rely on private sources to finance their businesses.

Government loans, especially SBA disaster loans, assisted businesses on damage repairs, mitigation, and operating expenses (e.g., payroll and material purchases) in the Harvey-declared disaster area. It took a few weeks to receive SBA loans after loan applications, otherwise the recipients would have to rely on other alternative financing sources.

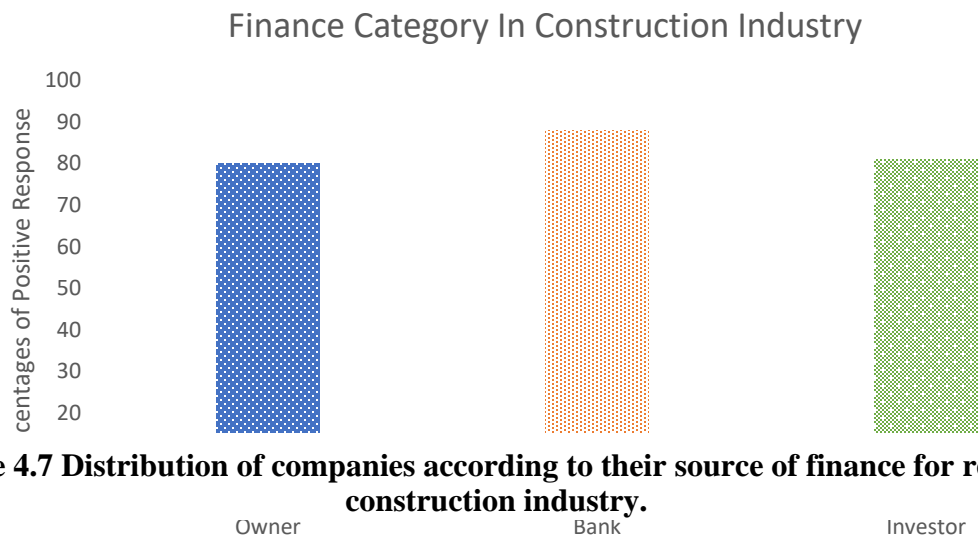


Figure 4.7 Distribution of companies according to their source of finance for recovery in construction industry.

Interviewees who successfully secured such loans confirmed the effectiveness of those loans but emphasized that small businesses must be made aware of what are available to them and be prepared for intensive application paperwork. Interviewees with proper property and builder's insurance coverage received funding for restoring their facilities and job sites, despite a long

processing time. In the meantime, several businesses were under-insured, did not carry comprehensive insurance coverages due to high premiums, which led to a delayed recovery. Small business owners were found to primarily using their personal fund or line of credit to cover their short-term disaster recovery needs before loan or insurance payments arrived or when the above financial resources were not available to them (e.g., did not qualify, were not aware, or applied but got rejected). This observation agrees with the past findings that recovery financing is commonly based on personal resources and earnings (Collier et al., 2020), and many owners are concerned about their ability to repay their loans, thus prefer self-funding rather than relying on loans (Alesch and Holly, 1996).

Upon further analysis, the access to a line of credit was shown to be an important factor for achieving full recovery (Figure 4.8). Small businesses that had access to funds from a line of credit were 10 percentage points more likely to recover than those without access to these types of funds.

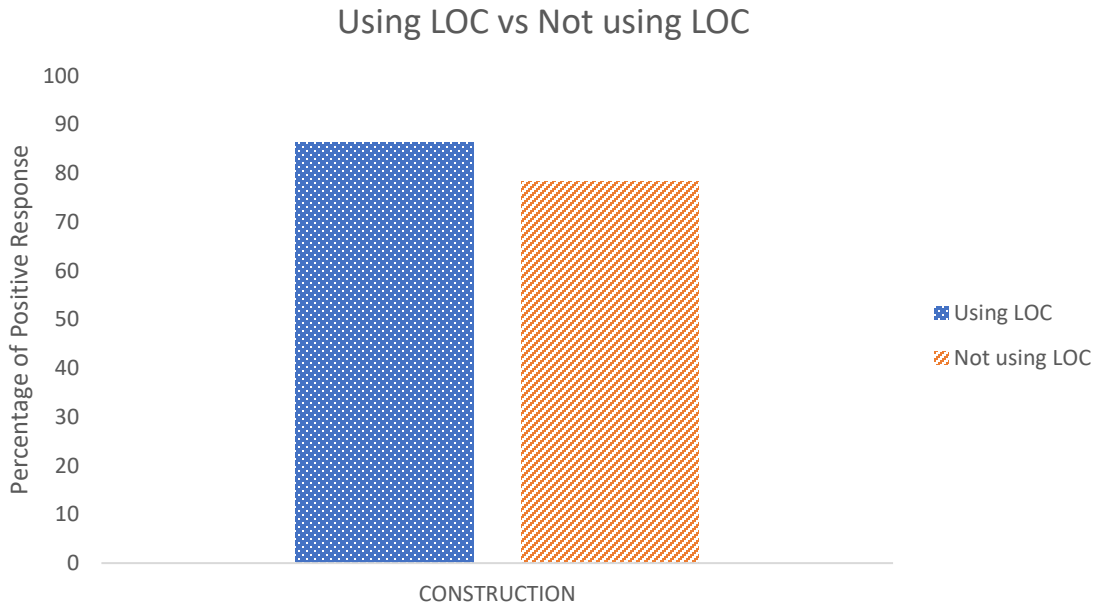


Figure 4.8 Percentage of participants who recovered using the Line of Credit (LoC) and did not use LoC.

4.5 Resilience practices and preparedness

According to the survey, small businesses that prepared ahead of time were more likely to recover. Almost half of the respondents made investment towards disaster resilience prior to Hurricane Harvey. These resilience-investing businesses reported a 92% recovery rate, 10 percentage points higher than non-investing firms (Figure 4.9). The interviewed businesses quoted a wide range of efforts in preparing their business against hurricanes and reviving their operation quicker to the pre-disaster level. Such efforts can be categorized as disaster preparedness and business resilience improvement.

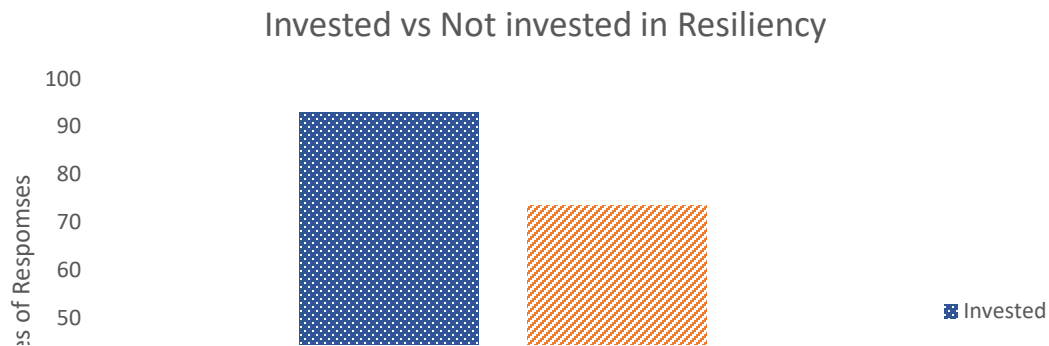
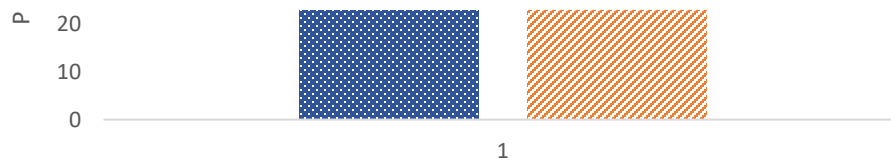


Figure 4.9 Percentage of construction companies who recovered based on investment in resiliency.



The preparedness behavior of businesses and the type of preparedness activities that they undertake play an important role in their recovery and economic sustainability following the disaster (Dahlhamer and Tierney, 1998). Some companies spend a lot of time, effort, and man-hours to be prepared for emergency situations such as a major disaster, while others might neglect

disaster and emergency preparedness plans altogether. Disaster preparedness herein includes efforts in response to a specific disaster type and characteristics (e.g., high wind, flood, freeze) to reduce direct physical damage to business properties (e.g., broken windows, flooded office, and loss of electricity) and restore their basic functions as quickly as possible.

According to the survey, the most popular mitigation measures adopted by all small business were backing up of computer files, use of emergency generators, installing flood barriers, and performing a review of their property with regards to safety. Specific to construction businesses, the interviews also found additional preparedness efforts as listed below:

- Planning: practices range from formal written emergency plan for the business (even to project- and disaster-specific plan, updated frequently) to informal communication protocols
- Communication: stay alert on inclement weather for proactive action; employee training; maintain good communication with clients
- Leadership and human resources: project superintendents play a critical role for job specific plan; involve clients in planning; remind and allow time for employees to prepare their homes for disasters
- Insurance: review insurance coverage (especially flood insurance) and get familiar with claim policy and procedure
- Resources: protect on-site equipment and materials; have necessary dewatering equipment, e.g., water pumps and power tools, on hand to prepare for flood water damage

Business resilience or business continuity efforts are about strategies to quickly resume business operation and recover work volume by protecting supply, demand, adapting business and

organization to changing market conditions immediate after a disaster as well as a longer term thereafter. Similarly, resilience strategies vary significantly from one business to another, reflecting the uniqueness characteristic of their business such as maturity, market positioning, and organization capacity (e.g., Boin and McConnell, 2007).

Following are the resilience strategies followed by our interviewees:

- Protecting material and labor supply: balance just-in-time and just-in-case purchasing strategies; identify a list of emergency and key materials and have in stock (e.g., pumps and moisture meters); job site storage solutions (e.g., box trailer) and surveillance
- Protecting demand/marketing and sales: strengthen business and maximize differentiation through certifications and recognition as minority businesses; diversify customer base and project types
- Introducing contractual protections: include force majeure clauses; keep complete project records for change orders and claims
- Investing in insurance: obtain more comprehensive insurance coverage
- Protecting cash flow: set aside emergency fund; diversify funding sources for disasters and economic hardship; learn about loan and grant programs and how to obtain fundings; negotiate for favorable payment terms, e.g., mobilization payment, shorter payment cycle, credit for partial work progress, reduced retainage; front loading project work; negotiate with vendors/suppliers for payment extension; advise and assist homeowners on obtaining insurance payment for project funding; improve financial forecasting and make sound decision based on historical data
- Adapting organization to changes (or not): decision about whether or not to adjust business scope (e.g., taking on emergency work, or remodeling and maintenance, or making no

change); rebalance subcontracting and self-performing work; adjust business focuses to reduce risks (e.g. civil/exterior vs. interior work); expand service geographic locations to reduce business risks and increase revenue; downsize and layoff

- Investing in technologies: digitize systems for better record protection and information management; digital tools for efficient communication with clients, e.g., proposals

The resilience investment behavior of businesses and the type of invested efforts that they undertake play an important role in their recovery and economic sustainability following a disaster (Dahlhamer and Tierney, 1998). While some companies invest heavily, others might neglect disaster and emergency preparedness plans altogether. To investigate the effectiveness of their resilience investment effort, we examined the relationship between the levels of resilience investment and recovery time of construction businesses based on the survey data. For simplicity, we consider businesses who self-reported moderate to a great deal of investment in preparedness and resilience as “investing business”, and the rest as “non-investing business” (i.e., reported little to no investment). As shown in Figure 4.10, despite both groups showing similar proportion of a quick recovery within 1-3 months, the “non-investing” group is clearly shifted toward a much longer recovery time. The mean time to recovery for investing businesses is 6 months, whereas for non-investing business, it is 9 months.

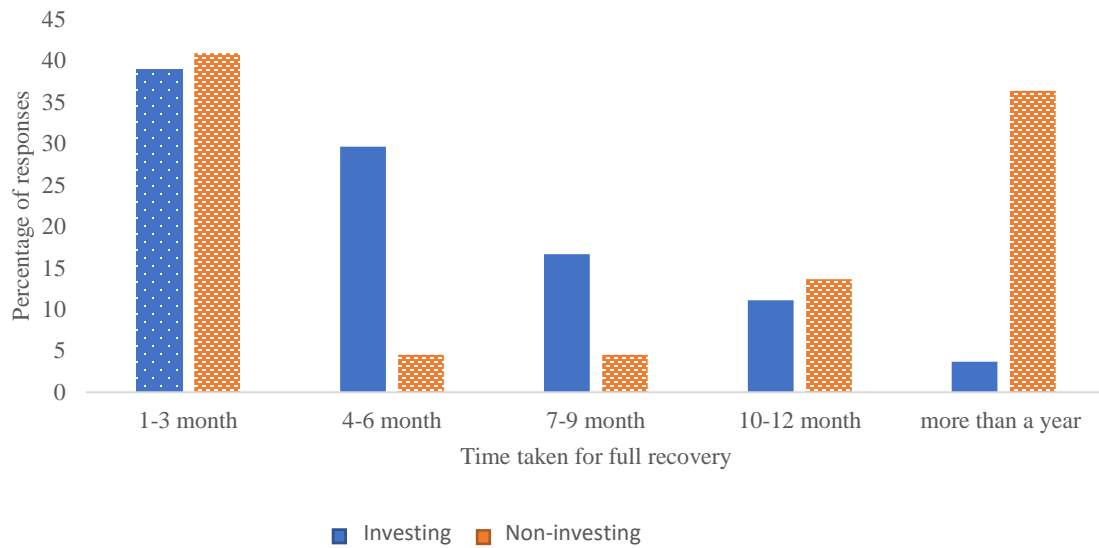


Figure 4.10 The relationship between resilience investment and recovery time.

A statistical Chi square test confirms that the difference is significant at a 95% confidence level. The actual data set is shown in Table 4.3. The expected chi square values are shown in Table 4.4. The chi-squared value was found to be $0.001 < 0.05$, hence the alternative hypothesis H1 – “there is statistical difference between investing and not investing with regards to time to recovery” is not rejected. The results show that the average recovery time for those who invested in the construction industry is approximately 6 months (Table 4.5), while those who did not invest have an average recovery time of approximately 9 months. As a result, those who have not invested in their business take 50% longer to recover than those who have.

This result may also be interpreted that a non-investing business is rather gambling on a disaster doing no harm to them; the result is almost entirely based on luck: if minimal disaster damage, they likely recover quickly, otherwise, a tougher recovery journey is awaiting.

Table 4.3 Actual time of recovery for Investing vs Non-Investing businesses.

Actual	Time to recovery		

		1	2	3	4	5	6	Total
	Investing	21	16	9	6	2	9	63
	Not Investing	9	1	1	3	8	7	29
	Total	30	17	10	9	10	16	92

Table 4.4 Expected time of recovery for Investing vs Non-Investing businesses.

Expected		Time to recovery						
		1	2	3	4	5	6	Total
	Investing	21	12	7	6	7	11	63
	Not Investing	9	5	3	3	3	5	29
	Total	30	17	10	9	10	16	92

Table 4.5 Keys for recovery time and month.

Key	Month	Key	Month
1	1	3.33	8
1.33	2	3.67	9
1.67	3	4	10
2	4	4.33	11
2.33	5	4.67	12
2.67	6	5	>12
3	7	6	not recovered

For further analysis, those who are prepared and invested in resilience recover at a rate of 89%, while those who are not prepared and not invested in resilience recover at a rate of 69%. Approximately 20% higher than those who are unprepared and uninvested (Figure 4.11).

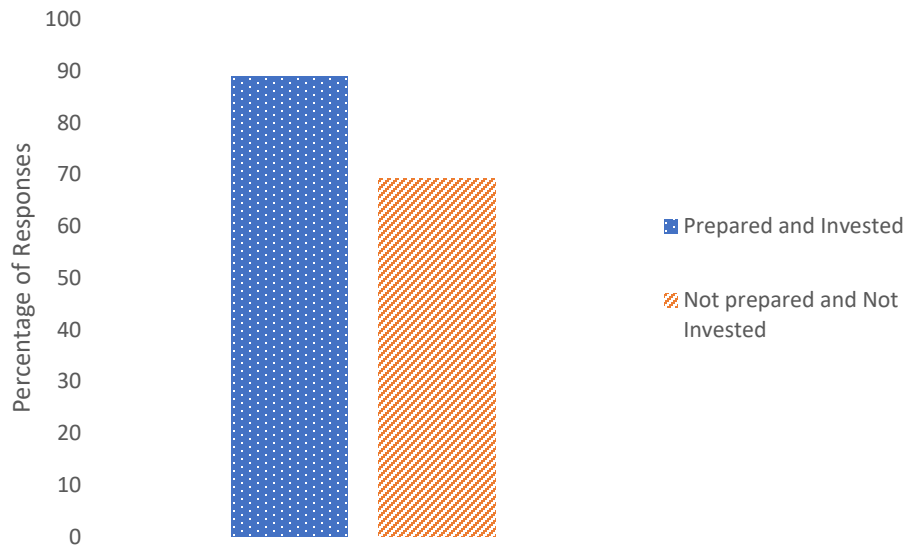


Figure 4.11 The relationship between prepared and investment in resiliency.

Those who prepared and invested their mean recovery time is about 6 months while those who are not prepared and not invested their mean recovery time is about 9 months.

Lessons learned reported by the interviewees include

- anticipate the unexpected and take control in reducing disaster related risk.
- disaster planning and documentation facilitates a better communication and engagement of stakeholders.
- investing in insurance is a smart business decision and worthwhile.
- small businesses need to increase awareness and how-to-obtain knowledge about various financing options including government grants and loans, and industry organizations and small business agencies can play the training role.

- small businesses must adapt to the changing and challenging market during post-disaster recovery.

4.6 Unique Challenges for Women Owned Businesses

According to the U.S. census, about 19.9% of the small businesses in the U.S. are owned by women. Of the 12 interviewed businesses, 5 are women and they are owners of their businesses. Literature review has indicated that women-owned businesses are exposed to higher risks and have a lower level of savings and insurance coverage (Fothergill, 1996), and they are more likely to fail than those owned by men (Marshall, 2015). Our small interview samples show 3 out of 5 women-owned businesses have significantly longer than usual recovery time, signaling additional challenges they had to face within the construction business.

Construction was and still is a male-dominated industry. Even women may self-perceive themselves as being less competitive than their male counterpart. They constantly feel the need to present a stronger persona—a personality that they present in public as opposed to their true-self, e.g., being more assertive and aggressive—to be able to fit in. In addition, they are likely to need to demonstrate more qualification (e.g., through more and better certifications) to substantiate their decision and recommendation to convince their male counterparts.

As an initial step to develop a better understanding of such challenges and their impacts, we asked the interviewees to comment on their unique experience during Hurricane Harvey on recovery. We discovered the following issues faced by them –

- Lack of knowledge about the loan process, bank, because of which they are unable to obtain the paperwork process for the loan, causing delays in grants and, in some cases, they are not qualified to apply at the right time.

- Manpower was the most difficult challenge for women-owned businesses, with some interviewees stating that due to a lack of manpower as a resource, they are unable to progress further for the damage repair required following Hurricane Harvey. This issue is directly related to the financing source because they do not have enough money to pay their workers. Therefore, they do not have enough recourse to recover quickly after a natural disaster.
- One of our female interviewees reported that using own family funds are more convenient option to finance the repair by Hurricane Harvey. They do not rely on banks because they are afraid of repaying their bank loans in time and incurring additional debt due to higher interest rates. Instead of a bank, they prefer a local vendor and private finance as their primary funding source because it allows them to build personal relationships with them and has a more flexible time limit than a bank.
- Some of them complain that the bank procedure was complicated because it took about 7 to 8 months for those who applied for loan grants to receive them, and the amount of grant they received was insufficient to cover the damages caused by Hurricane Harvey.
- "Better insurance can help to cover different types of damages caused by Harvey, but you must be aware of all the insurance policies and have a clear conversation with the insurance agent to avoid such an emergency situation and save time," said one female business owner.
- "Always plan ahead of time for emergency purchases so that you can recover quickly in the event of a disaster. Preparedness with such an emergency plan can save time and money in such an emergency. To accomplish this, we established a single emergency bank account specifically for this type of natural disaster," said one female business owner.

- Women business owners were most likely to rely on their own funds to finance the hurricane recovery effort, due to concerns about their capability in repaying a loan or incurring additional debt.

Additional efforts to follow up and communicate is usually required to reassure that they are serious and should be treated seriously. Meanwhile, being a women-owned business offers some unique project and grant opportunities, but they need to gain more exposure and be more aware of such opportunities. With more women and women-owned businesses in construction, the construction industry also needs to adapt to learn how to work with women.

5 CONCLUSION

The impact of Hurricane Harvey on small construction business and their recovery performance was studied based on an online survey and an interview study of 12 small businesses in the Harvey-impacted greater Houston area. The interviews solicited business owners' individual experience and opinion during the hurricane and recovery, including their definition of "full recovery" and recovery time; damages experienced to their business properties and job sites; the subsequent business impact on resource supply, market demand, contract administration, and cash flow; financing sources and experience in securing funding; their disaster preparedness and business resilience practices and lessons learned. Major conclusions can be summarized as below:

- Small construction businesses tend to use work volume as the primary measure of whether their business is fully recovered or not, followed by other minor indicators such as resume of field operations, project bidding; restoration of business property; normal material and labor supply.
- The mean recovery time is between 7 to 9 months for both construction and non-construction businesses without statistically significant difference.
- Resuming job site operation help to stabilize work volume and improve cash flow. Thus, job site condition has a larger impact on disaster recovery than home office condition for construction businesses.
- The market demand for disaster reconstruction changes from initial emergency work, to remodeling of building systems, and finally long-term restoration efforts. This investment pattern contributes to a sudden increase of demand immediately after the hurricanes, followed by some canceled/delayed projects but also new remodeling and restoration project opportunities.

- In addition to material delivery delay and price spike, the biggest challenge was labor shortage a result of multiple causes, including workers whose own home were damaged by the hurricane, road closure, high craft worker turnover due to competitions, and challenges in hiring.
- Force-majeure clause and comprehensive insurance (e.g., property, flooding coverage, and builder's risk) are the primary contractual mean for protecting contractors against disaster damages.
- Cash flow was a common issue for construction businesses, and it particularly made small business more vulnerable to disaster impact due to work stoppage, loss of revenue, and further delay of progress payments.
- Small business obtained funding from a variety of sources for disaster recovery, in particular government disaster loans and owners' own funding and line of credit.
- A wide range of efforts in preparing their business against hurricanes (i.e., disaster preparedness) and reviving their operation quicker to the pre-disaster level (i.e., business resilience).
- Lessons learned are related to the attitude toward disaster preparedness, disaster and emergency planning and communication, investment in insurance, awareness, and know-how about financing options, and being adaptive to market changes.
- The mean time for full recovery for resilience-investing businesses is 6 months, significantly shorter than the 9 months recovery time for non-investing business, confirming the value of investing in resilience.

- Women-owned business faces additional challenges in the male-dominated construction industry, such as perception of competitiveness, communication, financial resources, and staffing.

The interview study highlighted the unique nature of construction businesses and revealed distinct challenges and practice during disaster recovery. However, by nature, due to its limited sample size, it cannot verify the effectiveness of various resilience practices in a statistical sense. Future research should use more objective ways to measure their effectiveness, and based on that, to determine best practice to recommend to the business community.

6 FUTURE WORK

Future work for this project includes -

- Conduct more interviews with women business owners to quantify differences in recovery times.
- Perform a detailed study regarding SBA loan and FEMA emergency fund disbursement.
- Study geographical significance (county-wise data) for recovery efforts.
- Perform follow-up interviews to understand issues faced by businesses who take more than 1 year to recover.
- Create a timely post-disaster benchmarking index to inform relative recovery performance of a business.

REFERENCES

1. Auster, E.R., 1988. Owner and Organizational Characteristics of Black-and White-Owned Businesses: Self Employed Blacks Had Less Training, Fewer Resources, Less Profits, but Had Similar Survival Rates. *American Journal of Economics and Sociology*, 47(3), pp.331-344.
2. Boin, A. and McConnell, A., 2007. Preparing for critical infrastructure breakdowns: the limits of crisis management and the need for resilience. *Journal of contingencies and crisis management*, 15(1), pp.50-59.
3. Collier, B., Powell, L., Ragin, M.A. and You, X., 2020. Financing severe climate risk: evidence from businesses during Hurricane Harvey. Available at SSRN 3741812.
4. Corey, C.M. and Deitch, E.A., 2011. Factors affecting business recovery immediately after Hurricane Katrina. *Journal of Contingencies and crisis management*, 19(3), pp.169-181.
5. Dahlhamer, J.M. and Tierney, K.J., 1996. Winners and losers: predicting business disaster recovery outcomes following the Northridge earthquake.
6. Dahlhamer, J.M. and D'Souza, M.J., 1995. Determinants of business disaster preparedness in two US metropolitan areas.
7. Dietch, E.A. and Corey, C.M., 2011. Predicting long-term business recovery four years after Hurricane Katrina. *Management Research Review*.
8. Hiramatsu, T. and Marshall, M.I., 2018. The long-term impact of disaster loans: The case of small businesses after Hurricane Katrina. *Sustainability*, 10(7), p.2364.
9. Josephson, A. and Marshall, M.I., 2016. The demand for post-Katrina disaster aid: SBA disaster loans and small businesses in Mississippi. *Journal of Contingencies and Crisis Management*, 24(4), pp.264-274.

10. Keeler, Z., et al. (2022) Mitigation actions and small business recovery: evidence from 2017 Hurricane Harvey. 14th Americas Conference on Wind Engineering, Lubbock, TX, accepted.
11. Lee, J., 2019. Business recovery from hurricane Harvey. *International journal of disaster risk reduction*, 34, pp.305-315.
12. Marshall, M.I., Niehm, L.S., Sydnor, S.B. and Schrank, H.L., 2015. Predicting small business demise after a natural disaster: an analysis of pre-existing conditions. *Natural Hazards*, 79(1), pp.331-354.
13. Morrow, B. H., and Enarson, E. (1996). "Hurricane Andrew through women's eyes: issues and recommendations". *International journal of Mass Emergency Disasters*, 14 (1). PP. 5-22.
14. Olejarski, A.M. and Garnett, J.L., 2010. Coping with Katrina: Assessing crisis management behaviors in the big one. *Journal of contingencies and crisis management*, 18(1), pp.26-38.
15. Runyan, R.C., 2006. Small business in the face of crisis: identifying barriers to recovery from a natural disaster 1. *Journal of Contingencies and crisis management*, 14(1), pp.12-26.
16. SBA (2019). Table of size standards. <https://www.sba.gov/document/support-table-size-standards>, accessed March 1, 2022.
17. Scarinci, C., 2016. A post-superstorm sandy study of small business disaster preparedness and perspectives on planning for future incidents. *Journal of International & Interdisciplinary Business Research*, 3(1), pp.61-74.
18. Scheier, Robert L. "A dose of reality: nothing gives you a warts-and-all experience like testing your disaster recovery plan in the real world." *Computerworld* 19 Apr. 2004: 39.
19. Schrank, H.L., Marshall, M.I., Hall-Phillips, A., Wiatt, R.F. and Jones, N.E., 2013. Small-business demise and recovery after Katrina: rate of survival and demise. *Natural hazards*, 65(3), pp.2353-2374.

20. Turner, R.H., Nigg, J.M. and Paz, D.H., 2020. *Waiting for disaster*. University of California Press.
21. Wasileski, G., Rodríguez, H. and Diaz, W., 2011. Business closure and relocation: a comparative analysis of the Loma Prieta earthquake and Hurricane Andrew. *Disasters*, 35(1), pp.102-129.
22. Yoshida, K. and Deyle, R.E., 2005. Determinants of small business hazard mitigation. *Natural Hazards Review*, 6(1), pp.1-12.
23. Zhang, Y., Lindell, M.K. and Prater, C.S., 2009. Vulnerability of community businesses to environmental disasters. *Disasters*, 33(1), pp.38-57.

A. Appendix - Interview Questions

Interview Study – Business Name

Interviewee Introduction

- Name and contact information

Researcher

- Dr. Daan Liang, Professor of Civil Engineering with University of Alabama and Texas Tech University
- Dr. Bradley Ewing, Professor of Business with Texas Tech.
- Dr. Eric Cardella, Professor of Business Economics with Texas Tech.
- Dr. Lingguang Song, Professor of Construction Management with University of Houston
- Ankita Sahu, Research Assistant, University of Houston

Thank you for agreeing to participate in this interview study sponsored by US Department of Commerce. It will help to have a better understanding of the impact of Hurricane Harvey and the recovery performance of businesses in Harvey-impacted counties.

Participation in this interview study is voluntary. And the aggregated result of the study may be made publicly available, but NO individual identify, and personally identifiable information will be released.

Here is additional request, we hope to record this interview to better capture the interview data for this study but will not publish it or use it for any other purpose. We respect your preference, and you can opt in or opt out. [Get participant agreement; start recording and transcription].

Here is the agenda for the remaining time of this meeting. We will go through several questions to get your inputs. They are related to your business, impact of Hurricane Harvey, and your recovery experience.

Interview Questions & Response:

1. About you and the business:

Your position	Owner of the company
Primary market/sector	
Business type	
Service area	
Approx. gross annual revenue in 2017-2019	2017: 2018: 2019:
Time took to recover from Harvey	

The last question also leads to follow up questions.

2. How do you define “full recovery” of your business from a natural disaster like Hurricane Harvey? by comparing with your own pre-disaster condition or relative to your competitors?

By comparing financial, facility, or operation? Select multiple indicators (comparing to similar firms if needed and rank them in the order of importance.

Definition of Full Recovery	
Financial (e.g., revenue/profit/cash flow returns to the pre-disaster level)	
Physical/built environment (e.g., your property and equipment, community functions, transportation systems return to the pre-disaster level)	
Operational (e.g., employment/payroll returns to the pre-disaster level)	
Other	

3. How did Hurricane Harvey change supply chain, market demand, and business/contract administration? Which changes are temporary and which ones are lasting?

<p>Supply, e.g., labor, materials (lumber, drywall, paint, floor covering ...), equipment and power tools, subcontractors, facilities (access), and utilities (power, water, gas, communication ...) related to home and job offices</p>	
<p>Demand, e.g., surge or loss by percentage of new and existing projects and clients, type of work (plumbing, AC, interior, structural, foundation ...), change of market competitions</p>	
<p>Business/contract administration, e.g., contractual protection/dispute resolution, cost/schedule overrun and relief from clients, client progress payment, payment to subs/vendors ...</p>	
<p>Other</p>	

4. Specifically, what were the primary funding sources for Hurricane Harvey recovery (government loan, bank, private equity, owner financing/line of credit), their usage, and timing? What are the challenges and the lessons learned?

	Usage and timing
Government loan	
Bank, private equity	
Owner financing/line of credit	
Challenges	
Lessons learned	

5. Where have you invested in resilience (i.e., protect your supply and demand against Harvey, e.g. builder's insurance, disaster planning, inventory control, labor supply, anticipate cashflow shortfalls, contracting strategies, mobilization cost ...) both before Hurricane Harvey and after it?

Provide a list of investment actions to protect you against hurricanes? What about after Harvey?	
How effective these investment actions were?	
Considering the recent winter storm and current pandemic, which of the above investments also protect you against these disasters?	
Other	

B. Appendix – IRB Review

1 Objectives

The EDA funding will support an economic analysis of innovative financing strategies to advance the performance of small businesses and the overall region to better withstand disasters and provide adequate return to small-business investors.

Specifically, the proposed survey (Texas Tech) and the case study (University of Houston) will analyze the factors responsible for success of small businesses in

overcoming a sudden and severe economic dislocation and/or interruption caused by Hurricane Harvey of 2017.

UH team's case study interview questions will be submitted to the IRB for review and approval before being used in the study.

2 Background

Small businesses have long been an important driver of America's economic growth and competitiveness, providing outsized contributions to employment, innovation, exports, and productivity growth. However, many of them face challenges to attract investors and acquire effective levels of financing at the right time in the product or firm lifecycle to obtain an optimal capital structure (i.e., mix of debt and equity) thus restricting capital formation and value creation which depends on project/company valuation and capital formation. The problems of lack of financing are exacerbated for those whose operations are concentrated in disaster prone regions and lack means to diversify. FEMA reported that roughly 40-60 percent of small businesses never reopen their doors following a disaster.

3 Inclusion and Exclusion Criteria

This study involves a survey and a case study of small business in construction. The survey study will be conducted by Texas Tech University (TTU), and UH will be responsible for the case study. Small business in construction refers to general contract with a revenue below \$36.5 million and specialty contractors below \$15 million. The participation in the survey is voluntary. After the survey study completed by TTU, UH will select 10% of participating businesses for an in-depth case study. The selection will be based on the survey results. The research team will identify small businesses who successfully overcome the interruption caused by Hurricane Harvey, so the successful strategies can be identified.

4 Vulnerable Populations

N/A.

5 Number of Subjects

Local:

The TTU survey study involves a survey of 200-300 businesses and entrepreneurs of various sizes (with oversampling of small ones) located within 13 counties of Gulf Coast Economic Development District (GCEDD) to collect data on Hurricane Harvey caused damage, business interruption, recovery, and financing need. 10% or 20-30 those small business will be selected for the in-depth case study by UH. See Section 3.0 for selection criteria.

6 Recruitment Methods

Local:

TTU survey participants will be recruited with assistance from industry organizations, such as Associated General Contractors (AGC) and American Subcontractors Association (ASA). Based on the survey result, 20-30 information-rich cases will be selected for case study by UH. See Section 3.0 for selection criteria.

We plan to make first contact via email to verify availability to participate in the proposed case study. And in case of no response, a follow up phone call will be made. Please see script below for this initial contact, applicable to both emailed contact or phone call.

“Thank you for completing our recent survey of innovative financing strategies for small businesses. As a follow-up, we identified a small number of survey participants for a further in-depth case study, and we certainly hope you can consider this invitation for the case study with you. The goal of the case study is to elicit more specific details regarding your hurricane experience, planning (pre- and post-disaster), operational and financial conditions. The case study involves a face-to-face interview meeting at your office, or a teleconference (approximately 20 minutes) based on your preference and availability. Results of this study may be used in publications and presentations. However, individual names and other personally identifiable information will not be used in those publications. To further minimize the risks to confidentiality, we will be only stored the collected information in our secured university offices and computers, and the access to the data is limited to the research team. We do not intend to use or further distribute the collected data for future studies. Participation in this study is voluntary. Participation in this study will involve no cost to you. For more details, please see the cover letter.”

7 Multi-Site Research Communication

Please see above.

8 Study Timelines

The survey is expected to be conducted in 2019-2020 by TTU; and case study in 2020-2021 by UH.

9 Study Endpoints

9.1 Describe the primary and secondary study endpoints.

This is a minimal risk study.

9.2 Describe any primary or secondary safety endpoints.

There are no safety endpoints given that there are no safety risks associated with the study.

10 Procedures Involved

TTU: a survey of small businesses

UH: conduct case study based on survey results above.

- Select 20-30 small businesses (about 10% of survey sample size) for an in-depth case study analysis of their capital structures and methods of financing with respect to economic resilience and business expansion.
- The case study analysis would involve a phone or on-site (based on participant preference/availability) follow up interview approximately 20 minutes).

- The personnel interviewed from difference businesses are expected to be senior management or owner who are familiar with the operation and financial aspects of their organization.
- The case study will ask the participants more specific details regarding their hurricane experience, planning (pre- and post-disaster), operational and financial conditions. Final exact questions would be based upon findings from the broader survey and go in-depth allowing for more qualitative analysis.

11 Setting

The survey study involves primarily a survey (TTU), and on-site or phone interview with selected businesses for case study (UH).

12 Drugs or Devices

N/A

13 Risks to Subjects

This is an opinion survey (TTU) and case study (UH), no personal/individual information will be released. Results will be reported on an aggregated level. Case study description will not release any confidential information.

14 Potential Benefits to Subjects

The research findings will be converted into a series of easy-to-digest how-to guides posted on public websites. For small business owners, the guide will identify various risks, both in physical and economical dimensions, which can be caused by future hurricanes and outline effective strategies for continuing operation and growth.

15 Provisions to Monitor Data to Ensure the Safety of Subjects

This is a minimal risk study.

16 Withdrawal of Subjects

N/A

17 Costs/Payments to Subjects

Participants who complete the interview will receive \$150 to compensate for their time and effort.

18 Compensation for Research-Related Injury

This is a minimal risk study.

19 Confidentiality

Survey participants' name and contact information will be collected, however, this information will not be included and released in research reports and publications. Their contact information will only be used to identify information-rich cases for the follow up case study. Case study (UH) description will have all identifiers removed in research reports and publications. Collected data is not intended to be used or distributed for future studies.

20 Provisions to Protect the Privacy Interests of Subjects

Data will be report at an aggregated level, so no individual information can be identified.

21 Informed Consent Process

Consent will be obtained at the beginning of case study interview. Please see cover letter. We also like to request a "waiver of consent documentation" for this study as we will use a cover letter instead of a consent form to document consent from subjects. Please also note the following:

1. This research involves no more than minimal risk to the participants.
2. Written consent is not necessary for this research.
3. Written information describing the research will be provided to the subject.

22 Process to Document Consent in Writing

Please see statement above.

23 Data Management

Data collected will be stored in secured university computer servers. Data will be analyzed in SPSS. Only PI and RA will have access to the raw data. There is no plan to use the raw data set for future studies or shared with others.

24 Sharing of Results with Subjects

The research findings will be converted into a series of easy-to-digest how-to guides posted on public websites.

25 Resources

We will recruit graduate student from the Department of Construction Management to serve as RA, and the selected RA(s) will be trained to properly handle survey data and analysis to protect its confidentiality and integrity.