miyamoto. EARTHQUAKE + STRUCTURAL ENGINEERS

INTERNATIONAL DEVELOPMENT AND HUMANITARIAN ASSISTANCE

Responding to disaster and empowering countries to mitigate risk and improve lives worldwide

make the world a better, **safer** place.

CONTENTS

MISSION
make the world a better, **safer** place

PURPOSE
save lives, impact economies

Our goal is to **reduce vulnerability** and build resilience. Miyamoto is a technical leader and **trusted global partner** in preparedness, mitigation, response and recovery.

LETTER FROM THE CEO

\> I'm standing in the front of collapsed school in Sichuan, China in 2008. I know over 5,000 students are buried in this mass of concrete rubble. This should never happen again. This tragic event drives me and Miyamoto International. We are wholeheartedly committed and serious about disaster risk reduction.

To achieve the Sustainable Development Goals and to realize the Sendai Framework for Disaster Risk Reduction, both private and public actors must be ready to respond to a world of increasing complexity and risk.

With the frequency and intensity of natural disasters worldwide, our focus is on multi-hazard disaster risk reduction, response and recovery. Our approach is collaborative, actionable and data-driven,with the goal of protecting vulnerable countries and communities from the damaging economic, social and environmental effects of earthquakes and other disasters.

We also recognize that building resilience is multi-dimensional. While a global leader in technical structural, earthquake and hurricane engineering, we realize that effective disaster risk reduction is not only about the built environment but also how those structures interrelate with communities, governments and the private sector. Both context, and process matters. For this reason, we also prioritize capacity strengthening and policy advocacy in our programming.

The Sendai Framework highlights priority areas of action around understanding risk, strengthening governance, investing in resilience and building back better. Together with national and international partners, we have been implementing programming worldwide to advance these priority areas.

We are passionate and very committed to making the world a better, **safer** place.

Dr. H. Kit Miyamoto
President and CEO

70+	100	20+
Miyamoto International has served the world for more than 70 years	We have responded to more than 100 earthquake and hurricane events	We have more than 20 offices strategically located worldwide in earthquake-prone regions

Expert Services

Our expert services can be deployed to meet community needs and brought together to tackle the complex challenges inherent in pre- and post-disaster and post-conflict environments.

Built on decades of earthquake and structural engineering experience in the field, our expertise supports how countries and communities address the economic, political, socio-cultural, sustainability and technical challenges involved in risk reduction and post-disaster recovery. Miyamoto businesses are strategically located worldwide in earthquake-prone regions to impact economies and save lives.

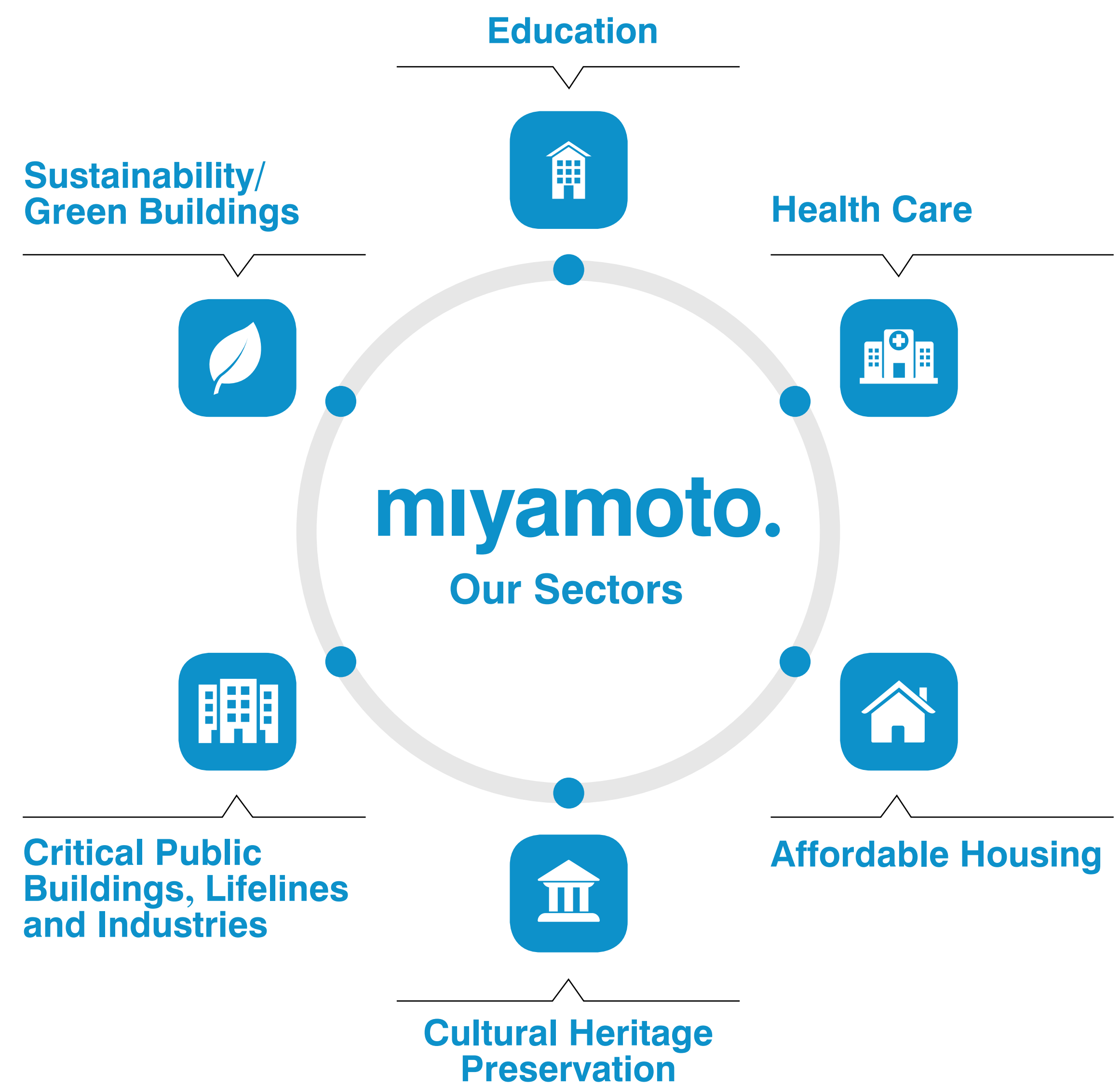
INTRODUCTION

Central to the mission of “making the world a better, safer place” is working with countries and communities worldwide on investing in resilient infrastructure and improved disaster management and response policies and practices. Building infrastructure resiliency is critical to sustainable development.

Similarly, continuously developing resilient disaster-response systems, capabilities and capacities through technical training and multi-stakeholder engagement and planning initiatives allows countries and communities to better understand the impacts of disasters and respond when disasters strike. Miyamoto captures and shares information on what is working well and what can be improved for continuous learning for both public and private actors.

Areas of Expertise:

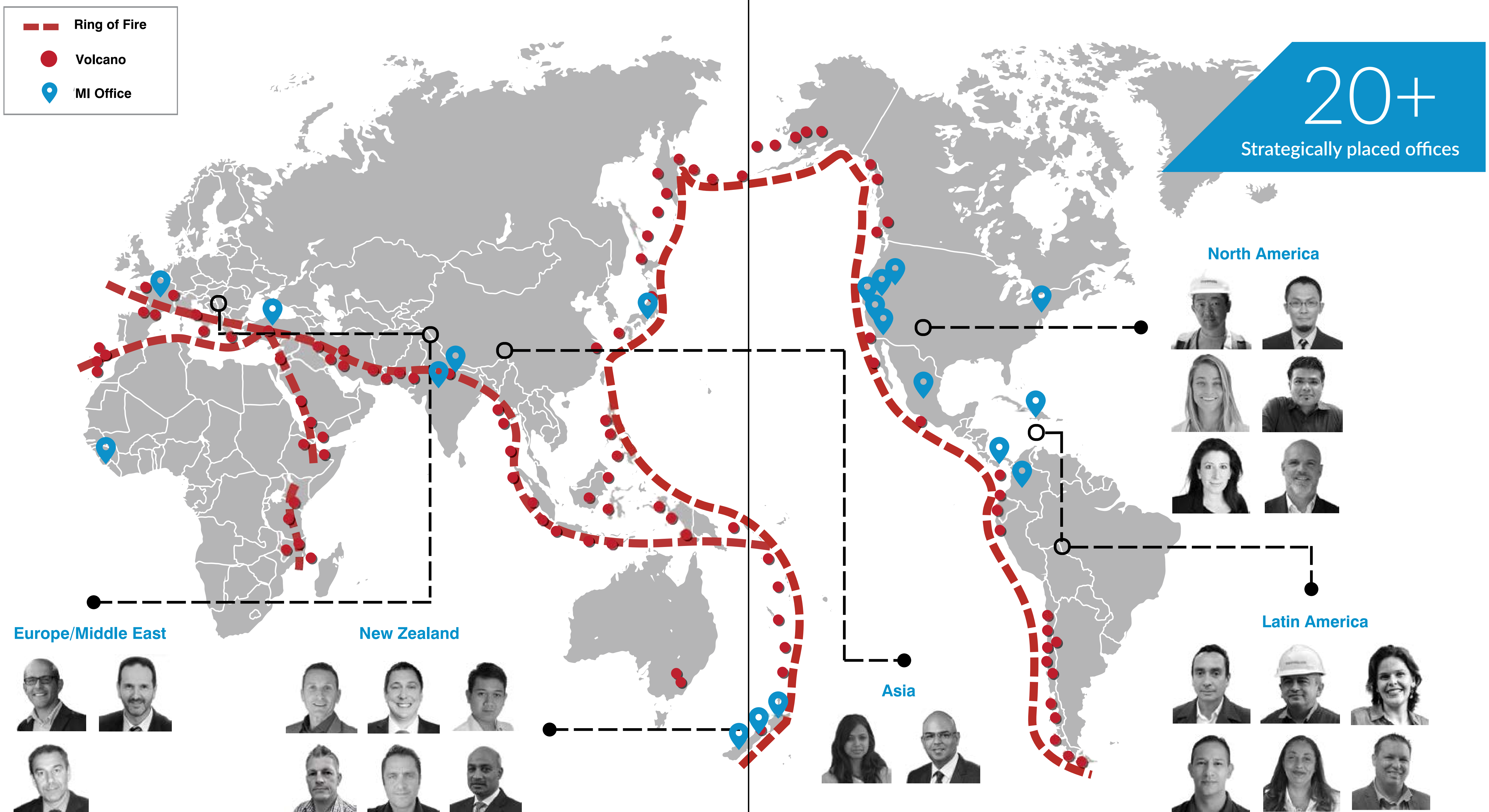
- **Disaster Risk Management Policy and Practice**
- **Multi-Hazard Disaster Risk Reduction**
- **Disaster Response, Early Recovery and Reconstruction**
- **Building Codes, Technical Capacity and Resource Development**
- **Urban Risk Identification and Modelling for Emerging Cities in Developing Countries**
- **Structural Engineering**
- **Geotechnical Engineering**
- **Construction Management, Supervision and Quality Control**



Our work builds resilience through local capacity development with our technical and programmatic team acting as a catalyst to support local leaders and institutions. We lead with world-class technical inputs while assisting countries and communities in turning that data into critical decision making by providing a unique and timely platform for country-led interventions.

Headquartered in California with an international development and humanitarian response-focused office in Washington, D.C., Miyamoto International has offices strategically positioned around the globe.

INTERNATIONAL DEVELOPMENT + HUMANITARIAN ASSISTANCE



Areas Of Expertise

Miyamoto's disaster risk reduction and management initiatives cover a range of activities with a focus on the mitigation or prevention of losses.

Typically, these areas include:

- Policies and Protocols: To promote resilience and advanced disaster risk reduction measures
- Institutional Strengthening: Including capacity development and training key agencies involved with disaster risk management
- Insurance and Risk Transfer
- Public Campaigns: Education for public awareness
- Hazard and Risk Mapping: Hazard and risk identification and assessments
- Urban Planning: Including analyzing the use of natural resources and zoning, as well as resiliency in building codes
- Engineering: Including structural and geotechnical analysis, resilient design, construction supervision and attention to materials
- First-Response Activities: Including issues of administration, management, communication and coordination

DISASTER RISK MANAGEMENT POLICY AND PRACTICE

Rapid and largely unmanaged urbanization in disaster-prone towns and cities is increasingly becoming a major driver of risk in the developing world. As the world's urban populations continue to grow, more people live in older buildings not built to life-safety standards, exacerbating problems related to unregulated new building development and land use. These challenges set the stage for increased economic and social losses from natural disasters, leaving urban populations highly vulnerable, particularly the urban poor. Many people are just one disaster away from poverty.

Pre-disaster efforts to improve disaster-response coordination and the ability of governments to carry out rapid and informed responses, early recovery and reconstruction decisions post-disaster can help lessen the potential hardships to disaster-affected communities and mitigate against the compounding economic and social impacts of a disaster. Miyamoto works to share lessons learned and the knowledge gained from its work in post-disaster environments across the globe with governments and the private sector seeking to strengthen their disaster-management capabilities and systems.

A critical component of this work is to support government stakeholders in gaining a better understanding of disaster risk. Prior to disasters, national and city officials often have only a general understanding of the impact that a disaster, such as an earthquake, will have on the built environment and its population. Miyamoto applies various scientific strategies to provide national and municipal disaster-management authorities with a clearer picture of the probable impact of a disaster, which helps inform and guide DRR/DRM policies and plans.

A key challenge is to turn scientific risk data into decisions. Miyamoto's international's development team is multi-disciplinary and experienced at facilitating political-planning processes around critical disaster risk reduction and post-disaster response activities – while also supporting their systemization and institutionalization. Working alongside government stakeholders to identify planning gaps, co-design strengthening measures or interventions, and provide technical assistance to help implement or update policies, plans and capacities for disaster-risk management governance allows Miyamoto to aid governments in their efforts to be better prepared to respond to disasters and protect their citizens.

Miyamoto is highly experienced in working with national and municipal governments in the aftermath of a disaster to support development and implementation of national, sector-specific or city response, recovery and reconstruction plans.

SCIENTIFIC DATA → POLICY DIRECTION → OPERATIONALIZATION → HUMAN CAPACITY DEVELOPMENT

Case Study

Preparing Rescue and Emergency Personnel to Ameliorate the Response to Earthquakes (PREPARE) in Costa Rica

OVERVIEW

At its core, the initial work of the PREPARE Program in Costa Rica was about countries and cities advancing and strengthening their own earthquake resilience to reduce lives lost, have less people injured and lessen economic disruption as a result of an earthquake. As a partner of USAID's Office of U.S. Foreign Disaster Assistance (OFDA) in Latin America and the Caribbean, Miyamoto International's role has been to support country and municipal leadership by providing world-class risk assessment data that could be used in decision-making around earthquake preparedness and disaster risk reduction. Through discussion and engagement with local leadership, this data highlighted opportunities for even greater preparedness initiatives. It was used as a foundation to connect people and resources to catalyze new ways of working and thinking around disaster preparedness and to reinforce local leadership and local ownership of the disaster preparedness agenda.

THE PROGRAM

The primary goal of the USAID/OFDA PREPARE Program is to strengthen and institutionalize the risk management and response capacity of public disaster authorities and private-sector partners in earthquake-prone and highly vulnerable urban settings. It is current being implemented in Costa Rica, Colombia, El Salvador and Mexico. This case study focuses on Miyamoto's work in Costa Rica.

The PREPARE program is made possible thanks to the support and generosity of the American people through the United States Agency for International Development (USAID) and its Office of US Foreign Disaster Assistance (OFDA)

Generally speaking, the PREPARE program has involved the following key actors for decision-making and action in Costa Rica:

- **National government representatives,** including but not limited to: The National Emergency Commission, the Ministry of Housing, Social Security and the Ministry of Public Health
- **Local government representatives,** including but not limited to: The Municipality of San José, through its Disaster Risk Management (DRM) office, its legal department, its environmental department, among offices
- National **geological survey** representatives
- **First responder organizations**, including but not limited to: Urban Search and Rescue (USAR) representatives, firefighters and police
- **Technical community representatives:** Universities, Distinguished national professors in field of engineering, professional associations (e.g. engineering associations) and research institutions
- **Private-sector** parties

TECHNICAL ASPECTS

The two main parts of the PREPARE Program were risk studies and data gathering and then turning that data into decision-making to reduce casualties and displacement and to lessen the social and economic impact of future earthquakes.

Risk Assessment

The first part of PREPARE was to gather data or use in the risk analysis of the built environment. The risk assessment took into account the various building typologies existing in the area of intervention and their vulnerability to earthquakes. For each target area, the quantification or inventory of people and buildings exposed to the effects of an earthquake (i.e. exposure model) was developed. This was done by subdividing the cities into a number of distinct zones that accounted for the distribution of building typology and land use. This exposure model was then used to analyze the overall impact, meaning the expected extent of building damage, number of fatalities and injuries, as well as the volume of debris that would result in the scenario of an earthquake. Spatial distribution maps of the earthquake risk of the city were then created through this analysis for the aforementioned stakeholders.

This information provided national and municipal disaster risk reduction institutions with a clearer picture of the probable impact of an earthquake. This information assisted them in meeting their preparedness goals to reduce casualties, displacement and to lessen the social and economic impact of future earthquakes. The risk-analysis work also examined the resilience of the heath care infrastructure in San José.

From the risk analysis came the following question for disaster risk reduction officials: Does the damage forecast provided by the risk assessment match the current policies, protocols and first responders/USAR's ability to respond to an earthquake? The response to this question assisted key national and municipal stakeholders in strengthening planning around and mitigation against the impact of a major earthquake.

Turning Data into Decision Making

Working closely with key disaster risk reduction leadership and institutions, critical gaps were identified in the following areas: (a) post-earthquake building security/damage assessments, (b) post-earthquake debris management, and (c) seismic resilience/risk identification of key public buildings critical for an effective response and early recovery.

Knowing the average volume of debris that can be generated by an earthquake in San José, the Miyamoto team, in conjunction with the Municipality of San José, identified the need to start working on a draft of a debris management strategy for the canton. As a first-of-its-kind initiative in the country, this involved the participation of various additional stakeholders with a role to play in such a scenario. This process and debris management document represents a significant step forward for Costa Rica in terms of earthquake preparedness.

In parallel, a valuable output of the risk assessment was the possible number of yellow- and red-tagged buildings that could result from an earthquake in the canton of San José. This information led to a discussion with the Ministry of Housing and other key institutions to assess a large number of houses in a short period of time after a disaster in an effort to support the decision-making of the highest authorities. Therefore, work started on three specific components of a scalable rapid damage assessment (RDA) system for housing: (1) the update of the current RDA tool for housing, (2) the development of an RDA manual/user's guide, and (3) a RDA App. The development of these tools will contribute to a more effective response after a major earthquake disaster in the country.

RESULTS

The PREPARE program launched in Costa Rica has proven to be an effective, replicable and scalable disaster-risk preparedness program in Latin America. It is now being implemented as a regional program with activities in Colombia, El Salvador and two parts of Mexico, Guadalajara and Mexico City. Due to high levels of stakeholder engagement and impact of the program outcomes, the scope of the program also has expanded further. The city-wide risk study that focuses not only on economic losses but also on social impacts has proven to be an effective advocacy and disaster-scenario planning tool that is being used by a broad range of stakeholders, from first responders and USAR teams, Ministry of Housing, the Ministry of Environment to both national and municipal disaster management authorities and officials. Looking toward institutionalization, progress also has been made on integrating key tools and curricula within universities and professional associations to be a resource to maintain the work over time. Local ownership and local relevance, key to the sustainability of this work moving forward, has been a cornerstone to the PREPARE approach and implementation on risk identification, preparedness activities and the related examination of legal, management and administrative frameworks around building seismic resilience.

MULTI-HAZARD DISASTER RISK REDUCTION

Natural disasters are inevitable. Risk can be effectively reduced through pinpointed, surgical interventions

Miyamoto tackles complex disaster-risk reduction challenges by employing a “surgical” approach. Whether analyzing the vulnerabilities of an individual or a large stock of buildings, Miyamoto works to identify the “weak links” in the system, which, if addressed, would have the biggest impact on the overall system’s performance or resilience. Natural disasters are not preventable and disaster risk cannot be eliminated. However, through pinpointed surgical interventions, risk can be effectively reduced and managed.

Miyamoto’s expert engineering team is specialized in carrying out cost-benefit analysis to help structure investment in disaster risk reduction by determining the most impactful interventions within specific budget guidelines. Given that there are limited resources and many competing priorities and urgencies, disaster risk reduction interventions need to be not only cost-efficient to be feasible, but their benefits must be effectively communicated to mobilize stakeholders to invest. When conducting cost-benefit analysis, variables that matter to stakeholders are analyzed. Whether the variables are loss of income or functionality/operations, or the number of fatalities that can be prevented using specific disaster risk reduction intervention, understanding the priorities of stakeholders, and drivers of decision making, is key to engineering successful disaster risk reduction efforts.

On behalf of governments, development partners and the private sector, Miyamoto has been engaged as a trusted implementation partner in the design and planning phases of disaster risk reduction strategies and interventions.

Working together with affected governments, businesses and families in the aftermath of disasters, Miyamoto is passionate about advocating for and supporting disaster risk reduction programming worldwide in disaster-prone countries.

> “We are a trusted implemenation partner in DRR strategies and interventions. ”

Case Study

Seismic Risk Mitigation and Rehabilitation in Istanbul, Turkey

OVERVIEW

The Istanbul Seismic Risk Mitigation and Emergency Preparedness Project (ISMEP) is widely hailed as a precedent and one of the most successful disaster-risk reduction programs worldwide.

Turkey resides along the major North Anatolia seismic fault line, making the risk of earthquakes, and earthquake-related damages extremely high. In August of 1999, a 7.6 magnitude earthquake struck near Istanbul, killing more than 18,000 people and injuring more than 50,000. Many structures collapsed or were severely damaged, with schools and hospital buildings suffering disproportional damage. Worldwide, a large percentage of schools and hospital buildings in areas of high seismicity are structurally deficient in construction, leading to severe damage and irrevocable collapse in cases of earthquakes and other natural disasters.

Since the 1999 earthquake, the city of Istanbul has grown substantially. The Government of Istanbul committed to systematic and extensive building strengthening of schools and hospitals throughout the city to mitigate against high casualties and tremendous economic losses, taking on board lessons learned from the 1999 earthquake. Working as a member of the Istanbul Seismic Risk Mitigation and Emergency Preparedness Project (ISMEP) team under the auspices of the World Bank, Miyamoto was imbedded within the Implementation Unit at the Government of Istanbul to support these efforts.

THE PROGRAM

The goal of the Istanbul Seismic Risk Mitigation and Emergency Preparedness Project (ISMEP) was to improve the city of Istanbul's preparedness for a future earthquake. There were three main objectives:

1. Enhancing institutional and technical capacity for disaster management and emergency response

2. Strengthening critical public facilities for earthquake resistance
3. Supporting measures for better enforcement of building codes

As a critical technical partner for the project, Miyamoto's primary role was to build technical capacity within the Government of Istanbul's Implementations Unit and provide quality assurance for the strengthening of critical public facilities for earthquake resistance, and building code enforcement measures. A large part of this effort was the development of guidelines for seismic retrofit of schools and hospital facilities in Istanbul, with the aim of safeguarding these buildings against a future earthquake. The project scope was intended to protect as many buildings as possible by using cost-effective methodologies while adhering to international standards and best practices.

TECHNICAL ASPECTS

Miyamoto's approach was an international-national team approach to ensure close collaboration between Miyamoto's international technical experts and national engineers for technology and knowledge transfer. This approach strengthened national capacity while still reaffirming and drawing on national engineering and construction knowledge and practices; both were critical to the success and sustainability of the work.

In order to identify, evaluate and retrofit or reconstruct as many vulnerable structures as possible with the available funding, Miyamoto and the Istanbul government developed guidelines for the selection and rehabilitation of vulnerable structures. The six key provisions to the guidelines follow:

1. **Condition assessment.** Data is gathered in sufficient detail to identify structural and nonstructural components that participate in resisting lateral loads, and potential seismic deficiencies in load-resisting components. As-built condition evaluations should utilize construction documents and testing, among other resources.
2. **Seismic deficiencies.** Common structural deficiencies, such as irregular configuration, non-ductile reinforcement detailing and URM infill walls are identified.
3. **Seismic hazard.** Seismic demands are defined in terms of design response spectra or suites of acceleration time histories. Hazards due to earthquake shaking are defined on either a probabilistic or deterministic basis.

4. **Analytical procedures.** Acceptable procedures ranging from simplified static to nonlinear dynamic analyses are defined based on structural configuration and retrofit.
5. **Structural performance levels.** Various performance levels are defined and the level of acceptable damage for each level is described. The appropriate performance level for a given earthquake intensity is identified.
6. **Retrofit.** Both conventional and innovative techniques are described. Innovative, but generally accepted methodologies are provided and encouraged.

RESULTS

To date, more than 2,000 schools and hospitals have been strengthened or reconstructed. It was found that in Istanbul oughly seven school buildings can be strengthened for every single building that would have needed to be rebuilt in the aftermath of an earthquake disaster. A key component of the program was to couple technical retrofit interventions with other non-structural architectural improvements at the schools. The visually improved (and now safer) conditions at the schools resulted in positive public perception and strong program support. In the development sector, the success of the ISMEP project was widely recognized and became known as one of the most successful systematic disaster risk reduction programs. Due to this project, Istanbul became an international showcase in Disaster Risk Management, and physical risk reduction. The guidelines established by Miyamoto continue to guide building codes and best practices throughout Turkey today.

Case Study

Multi-Hazard Disaster Risk Reduction in Metro Manilla, Philippines

OVERVIEW

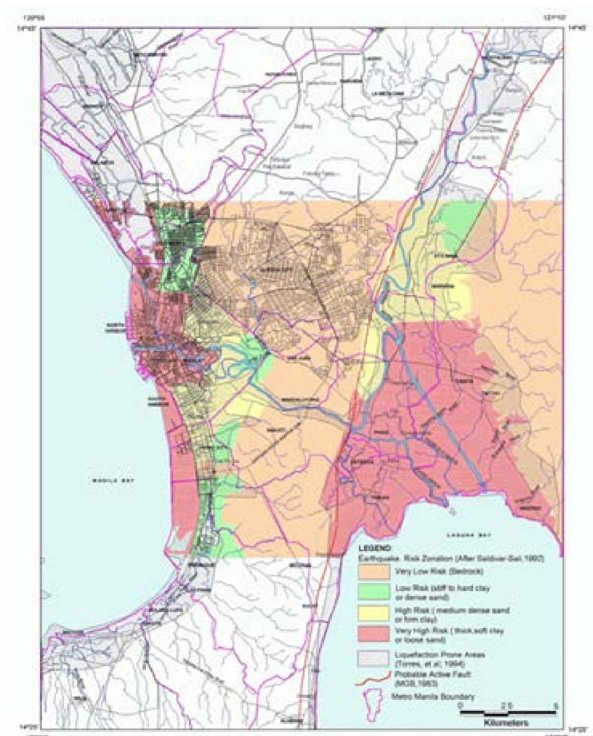
As evidenced by the M 7.2 Bohol earthquake in October 2013 and the Super Typhoon Yolanda that occurred the following month, the Philippines is a hot spot for natural disasters, ranking eighth among the most exposed countries in the world. The country is vulnerable to tsunamis and earthquakes, typhoons, floods and volcanic activity. Approximately 85 percent of the national GDP is earned in at-risk areas, most notably the capital city area, Metro Manila, which increases the country's vulnerability and further emphasizes the need for robust natural hazards risk mitigation programs.

Because of these realities, the World Bank contracted Miyamoto International to support the development of a multi-hazard risk mitigation and disaster preparedness program for Metro Manilla.

THE PROGRAM

The goal of the project was to conduct a multi-hazard risk assessment of Metro Manilla and cost-benefit analysis to guide investment and support the development of a risk mitigation program for the capital city.

In the first phase of the Metro Manila project, Miyamoto assessed the estimated number of fatalities and economic losses that would occur per natural hazard in order to start prioritizing investment in DRR. Based on this analysis, it was found that the fatality rate in the event of an earthquake occurring near the capital city, which was estimated to be 1 percent of the city's population, is a much larger magnitude than any other natural hazard for the area. This is due to the fact that a main fault line, the West Valley fault, runs across the entire metropolis. Furthermore, from



INTERNATIONAL DEVELOPMENT + HUMANITARIAN ASSISTANCE

a preliminary survey of the built environment of Metro Manilla, it was found that many key public buildings, in particular schools and hospitals, were densely populated and comprised of older multi-story buildings vulnerable to earthquake shocks.

TECHNICAL ASPECTS

Miyamoto trained national engineers in building assessment tools used by the team of engineers to collect building data on more than 3,800 public school and hospital buildings throughout the city.

The data was then utilized to develop seismic retrofit schemes specific to Philippine school and hospital construction, and conduct a cost-benefit analysis (CBA). The most vulnerable buildings to be prioritized for seismic strengthening were identified based on expected number of fatalities in these buildings in the case of an earthquake occurring during the daytime. The status quo, no retrofit, was used as the baseline, and the benefits derived from a seismic upgrade program and the costs associated with such an approach were quantified.

The prioritization of buildings for retrofitting exercise revealed that the seismic upgrade of the worst 100 school buildings (3 percent of inventory) would cost approximately $25-50 million USD. These upgrades would save more than 4,000 lives and preserve infrastructure that is substantially more valuable than the cost of the seismic upgrade. The 4,000 lives accounted for 18 percent of the total number of expected child fatalities in schools. By addressing the seismic vulnerability of an additional 100 school buildings through retrofitting, more than 25 percent of expected child fatalities in schools in case of an earthquake occurring during school hours would be reduced.

Under the program, the Guidelines for Seismic Retrofitting of Public Schools and Hospitals in Metro Manila were also developed in partnership with national engineers using the most internationally advanced yet cost-effective earthquake retrofit procedures tailored to local construction standards for these facilities. The guidelines allow for systematic strengthening of vulnerable public school buildings and hospitals in Metro Manila.

RESULTS

By focusing on the high impact an earthquake would have on schools and hospitals in Metro Manila, Miyamoto was able to conceive a first-of-its-kind, state-of-the-art prioritization methodology that mapped building vulnerability in terms of expected number of fatalities to guide DRR investment. In Metro Manilla, the damage to property, business interruption, areas affected, injuries and deaths, are higher in the event of an earthquake, compared to other natural disasters.

While it is important to prepare for multiple natural hazards, seismically strengthening buildings is critical to mitigate against loss. Based on Miyamoto's guidelines and findings, the Government of Philippines's interest was in seismically retrofitting 200 buildings, which would save more than 6,000 lives — a total of 25 percent of the total number of expected child fatalities — in the event of a future earthquake. Shortly after the study, Typhoon Yolanda hit the Philippines and focus shifted from DRR to response. Currently, efforts are underway to reinitiate critical DRR efforts in the metropole.

Areas of Expertise

Disaster Response, Early Recovery and Reconstruction

DISASTER RESPONSE, EARLY RECOVERY AND RECONSTRUCTION

Knowledge and experience from previous post-disaster responses enables Miyamoto to share best practices

Over the past 30 years, Miyamoto's engineers and technical specialists have responded to more than 100 natural disasters. When Miyamoto deploys its engineers and technical specialists to assist in the immediate aftermath of a disaster, local governments are often overwhelmed by the scope of the disaster and receptive to support and technical assistance. The knowledge and experience gained working in post-disaster environments enables Miyamoto to share best practices, what has worked and what didn't work well, assisting governments in developing and implementing response, early recovery and reconstruction strategies, plans and programs.

Following some of the most devastating earthquake disasters over the last decade, Miyamoto imbedded staff within government ministries and agencies to help guide response and reconstruction activities. In Christchurch, New Zealand following the 2010 and 2011 earthquakes, Miyamoto's team worked with the Christchurch City Council to develop the draft Central City Plan, which included short-, medium- and long-term plans for the city's recovery. Following the 2010 Haiti earthquake, Miyamoto worked with the Government of Haiti and development partners to design and implement the largest post-disaster damage assessment program of the time, which was the first to use a GPS (real time) data management system, resulting in the habitability assessment of more than 400,000 houses. In 2015, Miyamoto worked with the Government of Nepal's Ministry of Tourism to assess damages to the two most popular trekking routes in order to support recovery efforts of the tourism industry, which accounts for 40 percent of the country's GNP and was hard-hit in the 2015 earthquake.

Key to Miyamoto's approach is to work hand-in-hand with government stakeholders, but, critically, to also engage and work through the private sector and academia. In the developing world, Miyamoto seeks to gain a good understanding of the local business and operating environment, and is committed to supporting the development of local industry and technical capacity.

INTERNATIONAL DEVELOPMENT + HUMANITARIAN ASSISTANCE

EXPERIENCE: MORE THAN 100 EARTHQUAKES, 1971 - 2018

1971 San Fernando, CA (M6.5)
1972 Managua, Nicaragua (M6.3)
1973 Point Mugu, CA (M5.9)
1973 Managua, Nicaragua (M5.8)
1975 Ferndale, CA (M5.5)
1975 Lice, Turkey (M6.8)
1976 Friuli, Italy (M6.5)
1977 Vrancia, Romania (M7.4)
1978 Izu Peninsula, Japan (M6.7)
1978 Miyagi-Ken-oki, Japan (M7.4)
1978 Santa Barbara, CA (M5.1)
1979 Bishop, CA (M5.8)1979 Gilroy, CA (M5.5)
1980 Livermore, CA (M5.5 and 5.8)
1980 Eureka, CA (M7.0)
1980 Mammoth Mt., CA (M6.5, 6.5, 6.7)
1981 Brawley, CA (M5.6)
1983 Coalinga, CA (M6.7)
1983 Borah Mt., Idaho (M6.9)
1984 Morgan Hill, CA (M6.2)
1985 Santiago, Chile (M7.8 and 7.2)
1985 Mexico City, Mexico (M8.1 and 7.5)
1986 Painesville, Ohio (M5.0)
1986 Adak Island, Alaska (M7.7 and 6.5)
1986 North Palm Springs, CA (M6.0)
1986 Chalfant Valley, CA (M6.0 and 5.5)
1986 San Salvador, El Salvador (M5.4)
1986 Northern Taiwan (M6.8)
1987 Cerro Prieto, Mexico (M5.4)
1987 Bay of Plenty, New Zealand (M6.2)
1987 Whittier, CA (M5.9)
1987 Superstition Hills, CA (M6.3)
1988 Saguenay, Quebec (M6.0)
1988 Armenia, USSR (M6.9)

1989 Acapulco, Mexico (M6.8)
1989 Loma Prieta, CA (M7.1)
1989 Newcastle, Australia (M5.5)
1990 Upland, California (M5.5)
1990 Bishop's Castle, Wales (M5.4)
1990 Manjil, Iran (M7.7)
1990 Central Luzon, Philippines (M7.7)
1991 Valle de la Estrella, Costa Rica (M7.4)
1991 Sierra Madre, CA (M5.8)
1992 Erzincan, Turkey (M6.8)
1992 Desert Hot Springs, CA (M6.1)
1992 Cape Mendocino, CA (M7.0, 6.0, & 6.5)
1992 Landers-Big Bear, CA (M7.6 and 6.7)
1992 Cairo, Egypt (M5.9)
1993 Scotts Mill, OR (M5.3)
1993 Nansei-oki Hokkaido, Japan, (M7.8)
1993 Agana, Guam (M8.2)
1993 Klamath Falls, OR (M5.7)
1994 Northridge, CA (M6.6)
1994 Tohoko-oki, Hokkaido, Japan (M8.1)
1995 Great Hanshin (Kobe), Japan (M7.2)
1995 Pereira, Colombia (M6.5)
1995 Sakhalin Islands, Russia (M7.2)
1995 Antofagasta, Chile (M7.4)
1995 Manzanillo, Mexico (M7.6)
1996 Duvall (Seattle), WA (M5.3)
1997 Calico, CA (M5.0)
1997 Umbria, Italy (M5.5)
1998 Adana-Ceyhan, Turkey (M6.2)
1999 Armenia, Colombia (M5.0)
1999 Puerto Escondido, Mexico (M7.5)
1998 Adana-Ceyhan, Turkey (M6.2)
1999 Armenia, Colombia (M5.0)
1999 Puerto Escondido, Mexico (M7.5)

1999 Western Washington (M5.8)
1999 Izmit, Turkey (M7.4)
1999 Duzce, Turkey (M7.2)
1999 Central Taiwan (M7.6)
1999 Athens, Greece (M5.9)
1999 Algeria (M5.5)
1999 Hector Mine, California (M7.1)
2000 Napa, CA (M5.2)
2000 Tottori, Japan (M6.7)
2001 Gujarat, India (M7.6)
2001 Seattle, WA (M6.8)
2002 San Simeon (Paso Robles), CA (M6.5)
2007 West Sumatra, Indonesia (M6.3)
2007 Niigata (Kashiwazaki), Japan (M6.8)
2008 Mexicali, Mexico (M5.1)
2008 Wells, Nevada (M6.3)
2008 Sichuan, China (M8.0)
2008 Chino Hills, CA (M5.4)
2009 L'Aquila, Italy (M6.3)
2010 Eureka, CA (M6.5)
2010 Haiti (M6.9)
2010 Chile (M8.8)
2010 Baja California, Mexico & CA (M7.2)
2010 Christchurch, New Zealand (M7.2)
2011 Christchurch, New Zealand (M6.3)
2011 Honshu, Japan (M9.0)
2011 Van, Turkey (M7.2)
2012 Finale Emilia, Italy (M6.0)
2013 Philippines (M7.1)
2014 Napa, CA (M6.0)
2015 Nepal (M7.8)
2016 Ecuador (M7.8)
2016 Norcia, Italy (M7.0)
2017 Central Mexico (M7.1)

OVERVIEW

The January 2010 Haiti earthquake resulted in more than 230,000 deaths, affected more than 3 million people, and damaged or collapsed more than 200,000 structures. As a critical response activity and first step toward recovery, Miyamoto carries out rapid damage assessments within the first few weeks following a disaster.

Following the Haiti earthquake, an unprecedented post-earthquake building safety evaluation program was executed by the joint operation of the Haitian Ministry of Public Works, Transportation and Communication (MTPTC), Miyamoto International, the United Nations Office of Project Services and the Pan American Development Foundation, with funding support from donors, including the World Bank and the United States Agency for International Development's Office of U.S. Foreign Disaster Assistance. This program resulted in 600 national engineers trained in the fundamentals of earthquake engineering and building damage assessments and more than 400,000 buildings were assessed for structural safety in the affected areas of Port-au-Prince and Leogane. It was the largest damage assessment program of its kind worldwide.

THE PROGRAM

The program was undertaken with three strategic goals:

1. Understanding the extent of damage in the affected areas through carrying out building damage assessments
2. Developing a strategic reconstruction database
3. Upgrading the technical capabilities of Haitian engineers

Damage asssessments are critical post-earthquake as they are necessary to inform the public which buildings are safe to re-enter. After a disaster, there is a large number of internally displaced persons (IDPs) with nowhere to go. Without confirmation that their homes are safe to re-enter, affected people will remain in IDP camps and shelters, and an IDP crisis will continue to grow. Understanding the extent of damage is important for response and reconstruction planning and resource allocation.

TECHNICAL ASPECTS

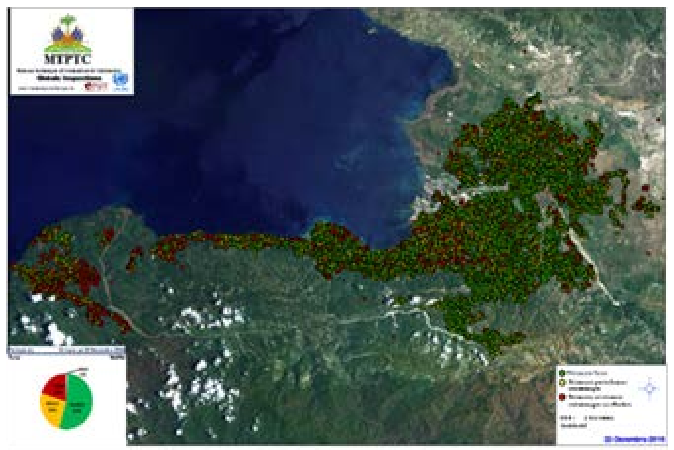
A modified version of the Applied Technology Council's ATC-20 technical platform, which accounted for Haitian building design, was developed. As part of this program, Personal Digital Assistant-based data collection techniques and quality assurance programs were implemented, and approximately 600 Haitian engineers were trained. As of March 2011, approximately 400,000 buildings had been inspected. This database was used to develop:

1. Repair strategies for yellow-tagged structures
2. Reparability, reconstruction, and demolition assessments of red-tagged structures.

When the results of the damage assessment of the 2010 Haiti earthquake were plotted on a map, the image that resulted was not a concentration of structurally damaged ("red-tagged") buildings surrounded by less damaged buildings ("yellow-tagged") with the undamaged or only lightly damaged ("green-tagged") buildings at the periphery, but rather a mixture of red-, yellow- and green-tagged buildings throughout the city (see photo).

INTERNATIONAL DEVELOPMENT + HUMANITARIAN ASSISTANCE

This kind of timely data was critical to provide the Government of Haiti and development partners with accurate damage data to inform decision-making and action. The data also helped to determine the allocation of resources to support reconstruction efforts and helped reduce the number of IDPs. Post-earthquake, there were 1.5 million IDPs in the region. Based on this assessment, thousands were able to return home.



Also central to this work was the capacity development of local Haitian engineers to implement the rapid damage assessment methodology and to better understand and address the core vulnerabilities of the building practices that contributed to the massive scale of post-earthquake building damage and/or collapse.

RESULTS

In the aftermath of the 2010 Haiti earthquake, 400,000 structures were assessed as a result of this program. Damage assessments post-disaster are critical for recovery, allowing IDPs to return home or identifying the need for repair and reconstruction. The planning of a reconstruction strategy within the affected area was also developed, and implementation began.

Based on the results of the damage assessments, yellow-tagged houses were further assessed for repair and certification in a large-scale effort funded by USAID, the World Bank, the Caterpillar Foundation, the Clinton-Bush Haiti Fund and the American Red Cross. More than 4,000 yellow-tagged homes were repaired in Port-au-Prince and an estimated 27,100 internally displaced persons were able to return to their homes and/or occupy them in full confidence that they had been repaired to a standard better than pre-earthquake condition. During the course of this program, more than 600 masons were trained in earthquake resistant repairs and construction, per the MTPTC Guideline.

Christchurch Central City Plan

LOCATION:
Christchurch, New Zealand

PROJECT DURATION:
April 2011 - April 2012

CLIENT TEAM:
Christchurch City Council

PROJECT BUDGET:
$10 Million

In April 2011, Miyamoto International NZ (formerly Impact South Island) became the project manager for the development of the Christchurch City Council's draft Central City Plan. The completed Central City Plan is an extremely significant document as it outlines the recovery for the city's Central Business District following the 2010 and 2011 earthquakes.

The Christchurch City Council (CCC) was given the task of developing short, medium and long-term plans for the central city's recovery. Part of that work was to create a new vision for Christchurch's central city that reflected the ideas of the greater Christchurch community. All aspects would be considered, from commercial opportunities and activities in public spaces to transport options and facilities available in the central city.

We were engaged by the CCC to provide project and programme management services. A structure and project culture had to be established that would deliver the draft Recovery Plan within the timeframe and criteria of the Canterbury Earthquake Recovery Act (CER Act). A programme also had to be developed that would implement the Plan in a way that met the objectives of the CER Act.

In leading the development for the Plan, CCC and Miyamoto International NZ had to engage with key stakeholders. These included CERA, Environment Canterbury (ECAN), and Te Rūnanga o Ngāi Tahu to ensure they could provide input into the Plan.

The community also needed opportunities to contribute their ideas and visions, and where appropriate, to have these reflected in the Plan. This led us to engage in one of the most extensive stakeholder engagement campaigns ever seen. Forums for consultation included the "Share an Idea" expo. Run over a six-week period, this generated 106,000 comments from the general public and wider communities. Road shows, public hearings, an International Speaker Series and a 48-hour design challenge hosted at Lincoln University were also held.

The scale of the devastation to the central city also meant the Plan had to be delivered in an 'impossible timeframe'. Through our leadership, the draft Central City Plan was adopted unanimously by the Christchurch City councilors on 11 August 2011. Miyamoto International NZ was recognised for their significant contribution. Director, Nick Regos was invited to attend the landmark meeting alongside senior council staff members. The team received a standing ovation, the first time in memory.

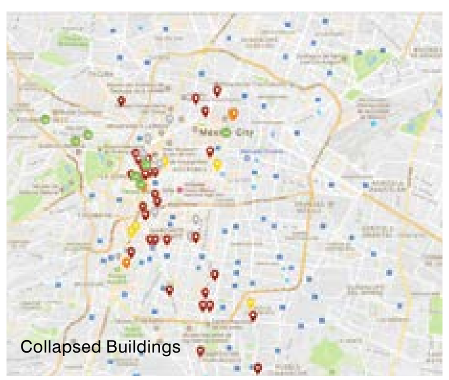
On the achievement, Nick commented "It was a very proud moment for the team, witnessing the gratitude and support for the over and above efforts that have been displayed by so many over the last three months. All councillors congratulated the team and the Deputy Mayor reminisced on her visit to San Francisco and commented that we could not achieve the impossible three month deadline that had been set, however we did it."

"Only when you view the volumes in their entirety do you fully appreciate the complexities, communication challenges, scale of work and compressed timeframes that have been successfully managed."

The Minister reviewed the CCC's draft Recovery Plan. Taking into account its impact, effect and funding implications, he came to the view that it could not be approved without amendment. In particular, there was insufficient information in the draft on how the Recovery Plan would be implemented. The Plan also proposed changes to the District Plan that were considered unnecessarily complex.

In response to these concerns, the Minister established a special unit within CERA, the Christchurch Central Development Unit (CCDU). The CCDU has been responsible for finalising the Plan and will lead its implementation in close collaboration with the Council, Te Rūnanga o Ngāi Tahu and other key stakeholders.

In September 2012 Miyamoto International NZ South Island director Nick Regos was recognised for his work and was named New Zealand Project Manager of the Year at the 2012 Project Management Institute (PMI) NZ Awards. Nick says the award is a fantastic recognition of the efforts the Miyamoto International NZ (formerly Impact) team and the Council staff have put in to developing the Central City Plan. As Impact, Miyamoto International NZ was also a finalist in two other categories in the 2012 Awards: Project of the Year and Public Sector Project of the Year, both for work completed on the Central City Plan.



Mexico Earthquake Disaster Response

LOCATION:
Mexico City, Jojutla

YEAR:
September 2017 (Ongoing)

CLIENTS:
USAID, CDMX, California Seismic Safety Commission

The initial goal of this technical assistance initiative was to help strengthen the capacity of municipal governments responding to the 2017 Central Mexico earthquake disaster. A team of Miyamoto earthquake engineering reconnaissance specialists arrived in hard-hit Mexico City to share technical knowledge, assist as needed and gather information on the impact of the earthquake for the California Seismic Safety Commission. Because this effort aligned with USAID/OFDA's objectives of providing technical assistance to disaster-affected municipalities, a USAID-funded project, the Mexico City Earthquake Response Program, emerged. The program provides critical technical assistance to support local response and recovery activities, including a "Training of Trainers" course for capacity building among the pool of structural engineers assessing 4,000 buildings affected by the earthquake. Program deliverables include a Detailed Damage and Reparability Assessment Methodology and Training Curriculum.

Ecuador Earthquake Disaster Response Initiative

LOCATION:
Ecuador

YEAR:
2016-2017

CLIENT:
USAID and various municipal goverments

The primary goal of this technical assistance initiative was to help strengthen the capacity of municipal governments and other partner organizations to respond to and mitigate against the impact of the 2016 April earthquake disaster. The activity responded to USAID/OFDA's objectives with the aim of providing technical assistance to at-risk and affected municipalities and communities in Ecuador. Additionally Miyamoto met with the municipal staff of Quito and Portoviejo and surveyed the cities, including informal construction in the city of Quito, which forms 60 percent of the residential construction. We also reviewed current and planned earthquake-response initiatives and provided recommendations for earthquake disaster-risk reduction. The recommendations included policy input aimed at reducing the risk in informal construction areas and establishing a coordinated damage-assessment program. Our work in Ecuador continues.

Nepal Earthquake Disaster Response Reconstruction and Mitigation

LOCATION:
Nepal

YEAR:
2015-2016

CLIENT:
Various

SCALE:
Magnitude-7.8

Miyamoto earthquake engineering experts landed in Nepal within three days of the April 2015, magnitude-7.8 earthquake to provide support to local entities responding to the crisis. In the immediate aftermath, many large organizations stepped up to provide immediate relief by supplying food and water, temporary shelter and medical support. While this support is critical, we provide expert earthquake structural engineering and reconstruction advice quickly, such as assessing whether homes and buildings are safe to re-enter and helping local government officials develop a plan for rebuilding or retrofitting to seismic standards that will withstand the next large earthquake. To date, we have more than 1,000 projects underway and completed ranging from damage assessments to retrofits for private and public clients. Our new office in Nepal advises local owners on structural assessments, urban and rural reconstruction, retrofits, structural design for new construction and quality control and construction supervision.

Tohoku, Japan

Earthquake Disaster Mitigation, Response and Reconstruction

LOCATION:
Northeastern Japan

YEAR:
2011

SCALE:
Magnitude-9.0

President and CEO Dr. Kit Miyamoto was presenting at an earthquake disaster mitigation conference in Tokyo when the magnitude-9.0 earthquake occurred, followed by a 29.6-foot-high tsunami. He immediately traveled into the affected areas, investigating and analyzing the damage on behalf of the University of Tokyo to give the Japanese Government critical information to help in the repair of the affected communities. Investigations included the failure of seawalls, conditions of structures and infrastructure and the cause of damages. This knowledge was used to educate Japan and the international community on planning and preparation for similar disasters to come. A thorough analysis of the local tsunami warning system was executed, including the emergency transportation system, emergency shelter facilities, and isolation of hazardous materials. More than 11,000 fatalities occurred and 400,000 people were left homeless as a result of the earthquake.

Areas of Expertise

Building Codes, Technology Transfer, Technical Capacity and Resource Development

BUILDING CODES, TECHNOLOGY TRANSFER, TECHNICAL CAPACITY AND RESOURCE DEVELOPMENT

The U.S. Presidential E-award recognized Miyamoto's exemplary export of technological knowledge worldwide

In the U.S., Miyamoto engineers serve on technical committees responsible for seismic design code development; a few of these are the American Society of Civil Engineers (ASCE) 7, the 41 Seismic Task Committees for new and retrofit of buildings, and the National Earthquake Hazards Reduction Program (NEHRP) base isolation and energy dissipation sub-committees.

Worldwide, Miyamoto has provided expert consultations, often times under the auspices of development partners, for governments in developing building code standards, seismic retrofit guidelines and other technical resources and manuals. Some of the countries Miyamoto has conducted this type of work include Romania, Turkey, Mongolia, Philippines, Indonesia, Nepal, Haiti, Mexico and Ecuador.

Through its capacity building programs, Miyamoto has developed and delivered technical, knowledge and technology transfer and disaster awareness trainings to a wide variety of people including government officials, and their staff of engineers and technical specialists, homeowners, masons, contractors, and engineers and architects from NGO partners and the private sector. Miyamoto engineers also serve as professors at universities and actively engage other professors and students in social-impact programs.

As part of its R&D, Miyamoto is also engaged in testing, researching and developing new technologies in earthquake engineering. The team has published hundreds of technical white papers and are frequent international speakers on seismic design and other disaster-mitigation and management issues.

> "We strive to transfer technical knowledge and build capacity. "

Case Study

Building Resilience in Ecuador

OVERVIEW

On April 16, 2016, a magnitude 7.8 earthquake hit Ecuador. Reports cited that the areas of Manta, Pedernales and Portoviejo accounted for more than 75 percent of the total casualties with at least 676 people killed, 16,600 people injured, more than 30,000 displaced and more than 9,700 buildings destroyed. Because of the coastal region's high seismicity, and large stock of non-engineered buildings not built to adequate construction standards, the majority of the population in the towns and cities along Ecuador's coast remain extremely vulnerable to earthquakes.

To mitigate against compounding the vulnerability of Ecuador's affected population, the Government of Ecuador requested targeted technical assistance from the United States to strengthening disaster risk reduction measures in reconstruction.

THE PROGRAM

The overall goal of the US Agency for International Development's Office of US Foreign Disaster Assistance's (USAID/OFDA) Building Resiliency in Ecuador Program was to help low-income populations gain access to knowledge and technical support for the use of disaster risk reduction-based construction materials and techniques in selected disaster-affected areas of high earthquake risk.

Three ongoing disaster risk reduction challenges were identified and have been addressed as a part of the program.

For the first challenge, many technical workers (e.g. masons, construction workers and others) had never received appropriate training on techniques that would result in safer construction and quality repairs. Further, very few construction workers have received

training on anti-seismic construction techniques. This reality resulted in substandard construction work carried out on a regular basis and led to greater risk in the event of a disaster.

For the second challenge, at the household level, many people did not have access to the appropriate technical support to ensure that home repairs or new construction were carried out in the best possible manner. Families investing their income and savings in rebuilding homes or constructing new homes needed information to be sure they are hiring qualified services and that high-quality materials are used in order to build back better and safer. Not being able to provide informed oversight of work or seek appropriate support at the household level also contributed to substandard construction work, which increased vulnerability.

In the third challenge, the knowledge and use of other disaster risk reduction friendly building materials had not yet been adequately mainstreamed in seismically vulnerable communities. Bamboo was emerging as a building material of interest for the most vulnerable populations because of its disaster risk reduction, resiliency qualities and cost-saving benefits, yet awareness needed to be raised and knowledge increased between homeowners and technical workers alike for this locally sourced and economically viable option. Therefore, trainings around the use of bamboo for disaster risk reduction and as a construction material were also a key part of this program for both homeowner and technical workers.

TECHNICAL ASPECTS

To meet these challenges, four different types of trainings, all relating to disaster risk reduction, were offered to technical workers and homeowners in earthquake-affected communities. For the technical workers, the trainings focused on using disaster risk reduction techniques and methods with an emphasis on the difference between traditional materials and bamboo. For the homeowners, trainings were centered on key concepts for building oversight and quality control, with one training relating to traditional materials and another relating to building with bamboo. All trainings served as a general communication tool for the use and mainstreaming of bamboo as a disaster risk reduction building material.

The activities were designed to empower technical workers to have the latest information on best building practices and to build local capacity. The activities also informed vulnerable homeowners, including women-headed households, on best disaster risk reduction building options available to increase consumer protection, particularly given limited financial resources, such as constructing with bamboo.

The training curriculum was a 16-hour course spread across four consecutive Saturdays. The training schedule was determined with the beneficiary communities to integrate within their existing commitments and work toward full and engaged participation throughout the life of the program. The curriculum featured participatory training methods with detailed modules on safe building practices and also on building with concrete and building with bamboo. The course also featured demonstrations and hands-on training. A training brochure and manual were developed for the course.

The programmatic approach of this work was to strengthen and empower local capacity for sustainability. Key decision making was done in concert with local partners through a Steering Committee with activities aimed at delivering targeted trainings and capacity building activities to masons and technical workers. The Steering Committee members include the Pacific International Center for Disaster Risk

Reduction, the Universidad Laica Eloy Alfaro de Manabi (ULEAM) and Save the Children in Ecuador.

RESULTS

By the end of the program, nearly 500 people were trained in safer building practices using bamboo and commonly used construction materials such as concrete, steel and brick. Initial disaster risk reduction challenges identified around technical knowledge transfer and homeowner empowerment also were addressed. Miyamoto worked closely with its partners to explore the further development and delivery of disaster risk reduction trainings in Ecuador o continue to promote the use of bamboo as a locally available, cost-effective and quality building material or safe and resilient structures. The program also generated communications materials about better building practices for broader dissemination and reach.

INTERNATIONAL DEVELOPMENT + HUMANITARIAN ASSISTANCE

Utilizing Bamboo as a Disaster Risk Reduction Tool

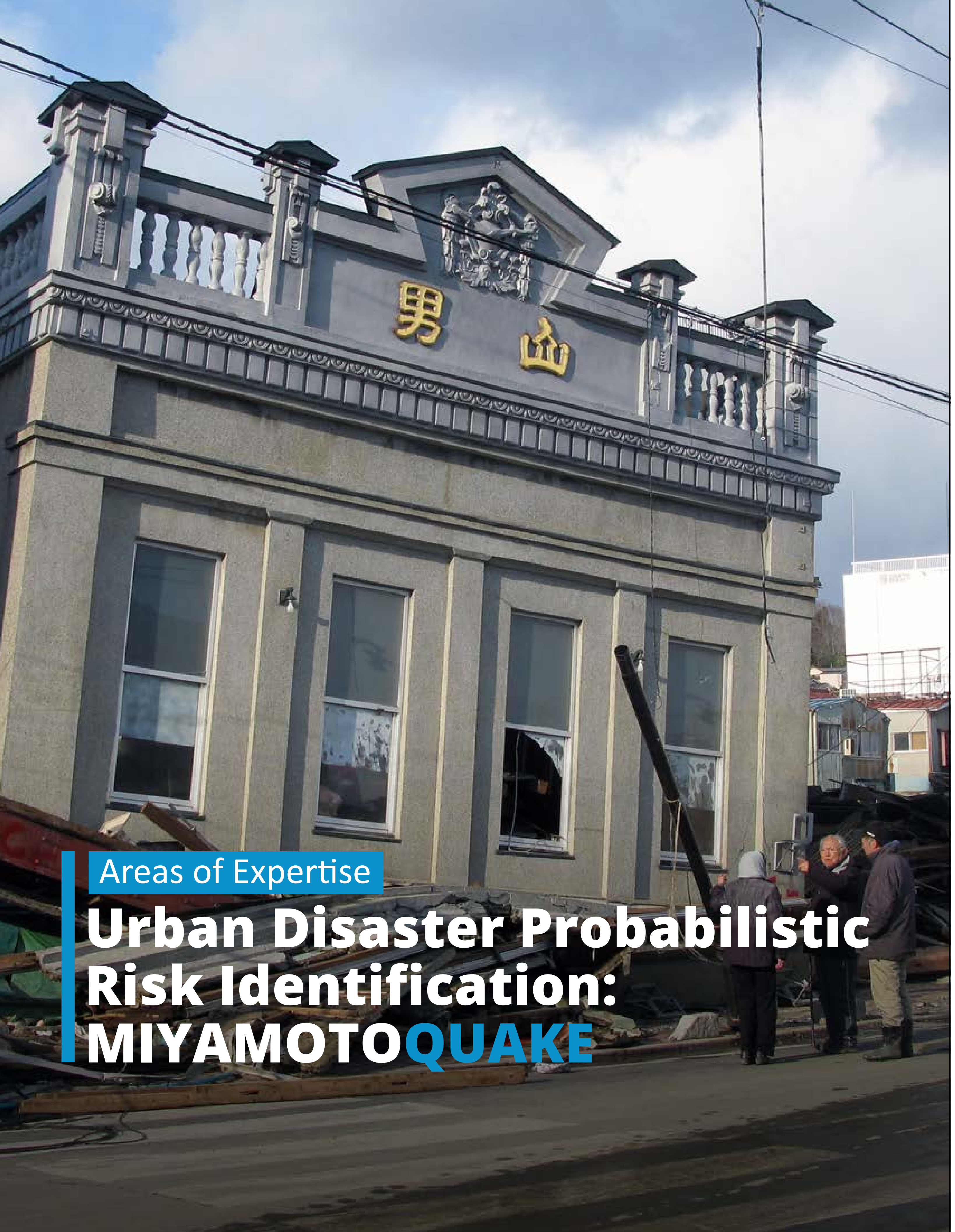
Concrete and brick construction remain the most widely used building materials in Ecuador's coastal towns. However, one important, more affordable, locally available and disaster risk reduction viable building material is bamboo. Bamboo is a natural resource available in the country and can provide homeowners with an economical and disaster risk reduction friendly construction alternative.

Bamboo has been emerging as a building material of interest for the most vulnerable populations for its disaster risk reduction, resiliency and cost-saving benefits. Yet, awareness must continue to be raised and knowledge increased between homeowners and technical workers alike of this useful and locally sourced option. Therefore, trainings around the use of bamboo for disaster risk reduction and as a construction material were a key part of the USAID/OFDA Building Resilience in Ecuador Program for both homeowner and technical workers.

This type of intervention also builds on increased local awareness and observation of how well bamboo structures performed in the 2016 earthquake, as they did not experience the mass damage or collapse of other construction types during the earthquake. Therefore, this intervention also builds on the dominant perception that there is community interest in building with bamboo for greater resiliency, but the technical knowledge is not adequately available.

In addition to others areas, including hands-on sessions, the bamboo trainings:

- Shared examples of successfully completed bamboo projects in the Latin America and Caribbean region
- Included descriptions of strong bamboo interconnections and design details, which formed the basis of stronger/safer constructed product



URBAN DISASTER PROBABILISTIC RISK IDENTIFICATION: MIYAMOTOQUAKE

Countries like Japan and Italy that frequently face major urban earthquake disasters are better equipped to design disaster risk reduction (DRR) plans that help mitigate the impacts of future disaster events. This is because the public understands that earthquakes are an imminent threat; widely held recognition that investing in DRR today will save lives and protect the country's economic wellbeing also exists. In countries that lack recent earthquake experience yet remain highly prone and vulnerable, it is paramount to articulate what the impact of an earthquake may look like by developing a realistic disaster scenario to engage the public and private sector, and international development community. Using risk modelling is an evidenced-based approach to DRR.

Over the last 30 years, Miyamoto has developed a comprehensive database on all types of buildings in diverse geographical locations and their respective fragility or resilience in an earthquake. Miyamoto's risk engineering team has further advanced this large bank of data into a risk analysis model, known as MiyamotoQuake. Utilizing a state-of-art approach to probabilistic analysis, MiyamotoQuake helps us better understand risk by identifying probabilistic disaster outcomes, and providing a realistic picture of the impact of an earthquake on a population and its built environment.

MiyamotoQuake is unique in that the probabilistic outcomes are focused on social consequences of earthquakes, including expected number of fatalities, injuries and internally displaced people (IDP), expected number of light- medium- and heavily damaged buildings and the volume of debris. It does more than just narrowly focus on financial risk and economic loss as with most other risk-analysis platforms. MiyamotoQuake is suited for guiding DRR planning and investment in developing countries.

Miyamoto has extensive experience in supporting governments and development partners to use this data and the scenarios as advocacy and planning tools guiding action for disaster risk reduction and greater resilience.

The team also has expertise in using other open source risk modelling platforms, such as HAZUS and the Global Earthquake Model's OpenQuake.

Areas of Expertise

Structural Engineering

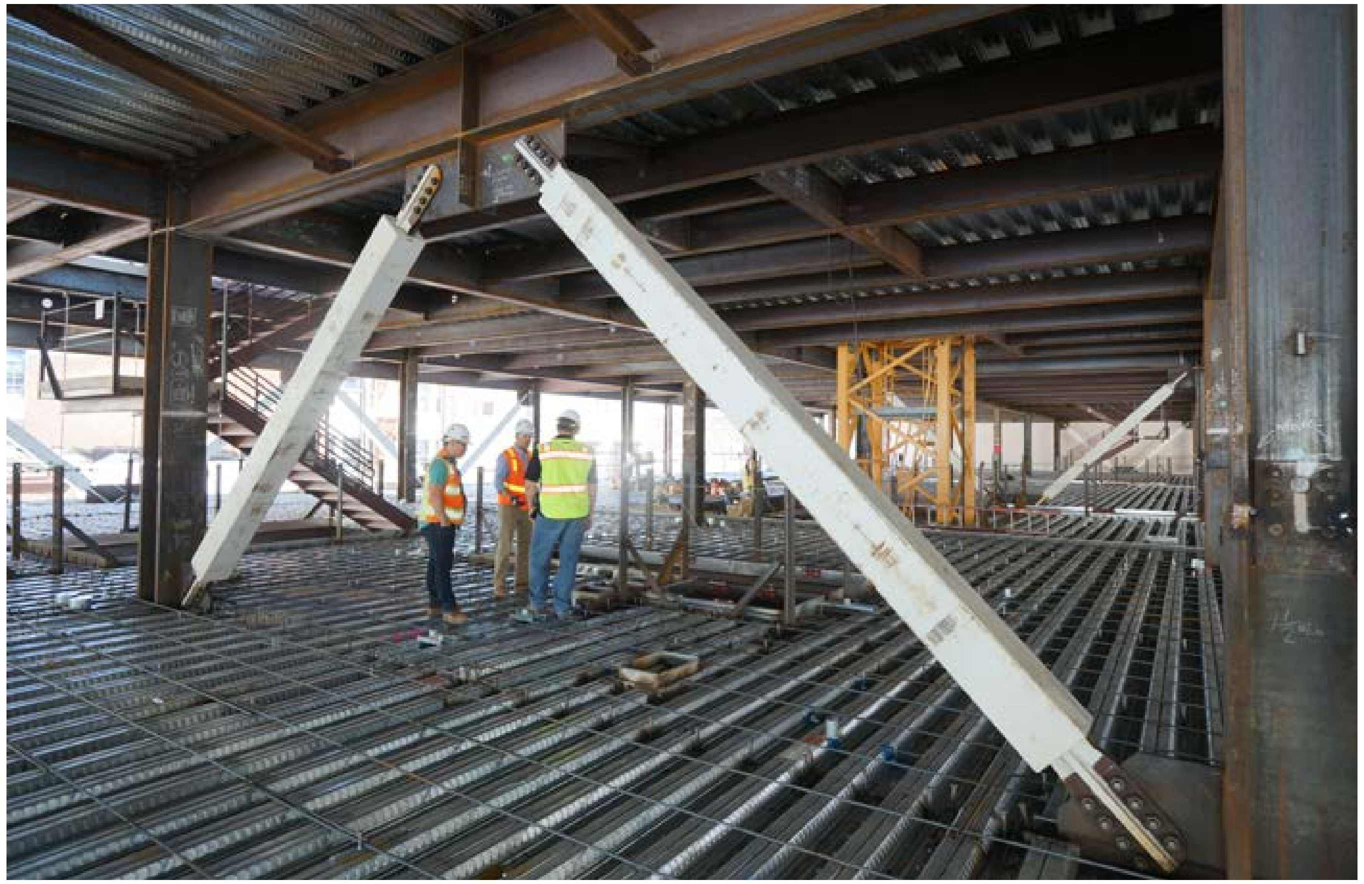
STRUCTURAL ENGINEERING

The broad range of structural engineering services Miyamoto offers include:

- **Hurricane and earthquake structural damage and safety assessments**
- **Structural designs, repairs, upgrades and retrofits for new and existing facilities, buildings and bridges**
- **Building codes, standards, guidelines and other technical resource development**
- **Technical training and capacity building**
- **Construction supervision and quality control**

Miyamoto has assessed thousands of buildings pre- and post-disaster for their structural safety. Prior to disasters, structural safety concerns of infrastructure are not properly addressed, leading to lives lost and great economic losses. During the aftermath of a disaster, many buildings that have sustained damage and are repairable are needlessly torn down, due to lack of engineering knowledge. This can prolong the hardship of affected populations and the local economy. The knowledge and experience gained by working in post-disaster environments, and the firm's vast library of building-performance data, informs Miyamoto's practical approach to assessing and addressing the structural safety of infrastructure.

Building and infrastructure safety evaluations need to be prudent in order to help reduce risk to life and injury in the event of a disaster – however, evaluations cannot be so overly conservative they make interventions economically unfeasible, displace people from their homes or needlessly close schools, businesses and other critical facilities. The recommendations Miyamoto provide are geared toward protecting lives and reducing risk, while also saving infrastructure and maximizing the impact and value of infrastructure and DRR investments.

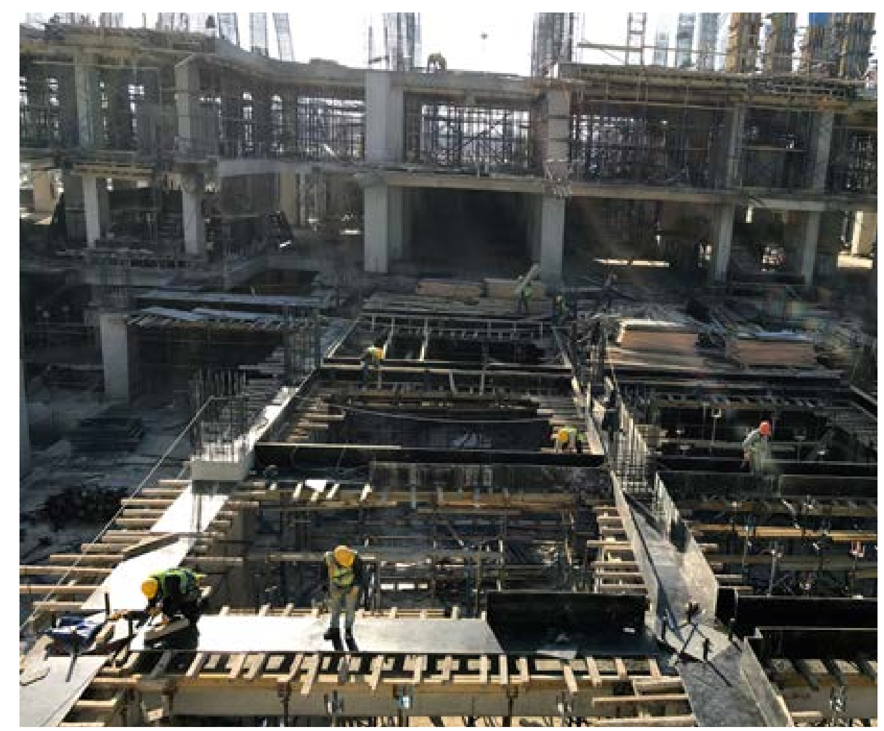


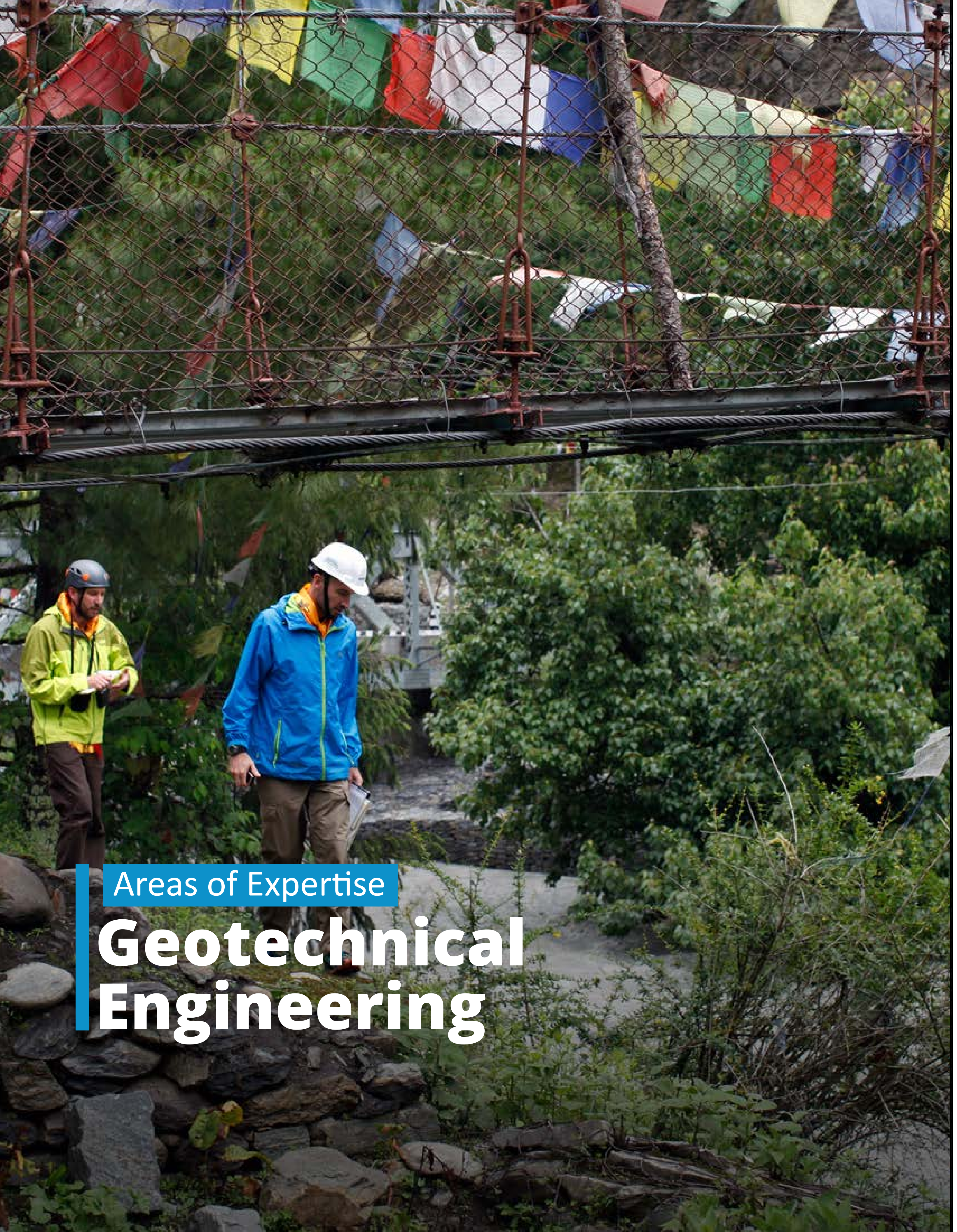
Miyamoto is passionate about the resilient design of new infrastructure. We are experts in performance-based engineering, which allows us to design for higher resiliency. Whether rural healthcare facilities or urban multi-story school buildings, Miyamoto works to find cost-efficient and effective ways through design to protect critical structural elements, such as the frame of the building, from earthquake shocks and hurricane winds – helping to improve the resiliency of infrastructure and communities.

We are similarly passionate about retrofitting or seismically upgrading existing buildings. Our expertise in the assessment, prioritizing and retrofitting of aging buildings allows us to vigorously address and remedy the shortcomings of poor or outdated engineering and construction practices by incorporating global best practices from countries that have conducted extensive and systematic strengthening of structures. Miyamoto's retrofit approach is "surgical" —we focus on understanding and addressing the main weaknesses of a building. This allows us to strengthen a structure's overall ability to withstand earthquake or hurricane loads.

Cost-effectiveness and life safety are key.

INTERNATIONAL DEVELOPMENT + HUMANITARIAN ASSISTANCE





GEOTECHNICAL ENGINEERING

Miyamoto's geotechnical engineering team is based in Christchurch, New Zealand. In recent years, the team has grown organically with a number of hand-picked professionals with a diverse range of experience and expertise that can be drawn together to provide the right set of skills for any project. Geotechnical engineering is critical to the stability of a structure. Miyamoto offers an extensive range of services in the field of geotechnical engineering, including:

- **Geotechnical investigations**
- **Site (in-situ) and laboratory testing of soils and rocks**
- **Construction monitoring**
- **Bearing capacity of shallow and deep foundations**
- **Settlement analysis**
- **Geotechnical foundation design (mat, raft, piled foundations and shafts)**
- **Geotechnical earthquake engineering**
    - **Soil liquefaction assessment and risk analysis**
    - **Probabilistic seismic hazard analysis**
    - **Site response analysis – selection of hazard consistent time histories**
    - **Soil-Foundation-Structure-Interaction**
    - **Advanced stress-strain numerical modelling**

- **Ground treatment (ground reinforcement and/or improvement)**
- **Slope stability analysis and design for soil and rock slopes**
- **Settlement analysis**
- **Earthworks and retaining structures (timber pile, sheet pile, concrete and block walls, diaphragm walls, secant piles)**
- **Reinforced embankments and Mechanically Stabilised Earth Walls (MSEW)**
- **Dams**
- **Rock fall assessment and rock mechanics**
- **Land stability and monitoring**
- **Peer reviews**

In particular, Miyamoto considers itself one step ahead of the market with regards to Soil-Structure-Interaction and Performance-Based Engineering. With direct access to its in-house structural engineering team, Miyamoto can efficiently develop a comprehensive understanding of the ground and structural performance and maximise the efficiency of structural elements. With a better understanding of the seismic performance of the ground and structures, Miyamoto can produce design solutions with measurably reduced risk and costs.

CONSTRUCTION MANAGEMENT, SUPERVISION AND QUALITY CONTROL

Miyamoto has developed construction-supervision tools and methods for remote and challenging environments

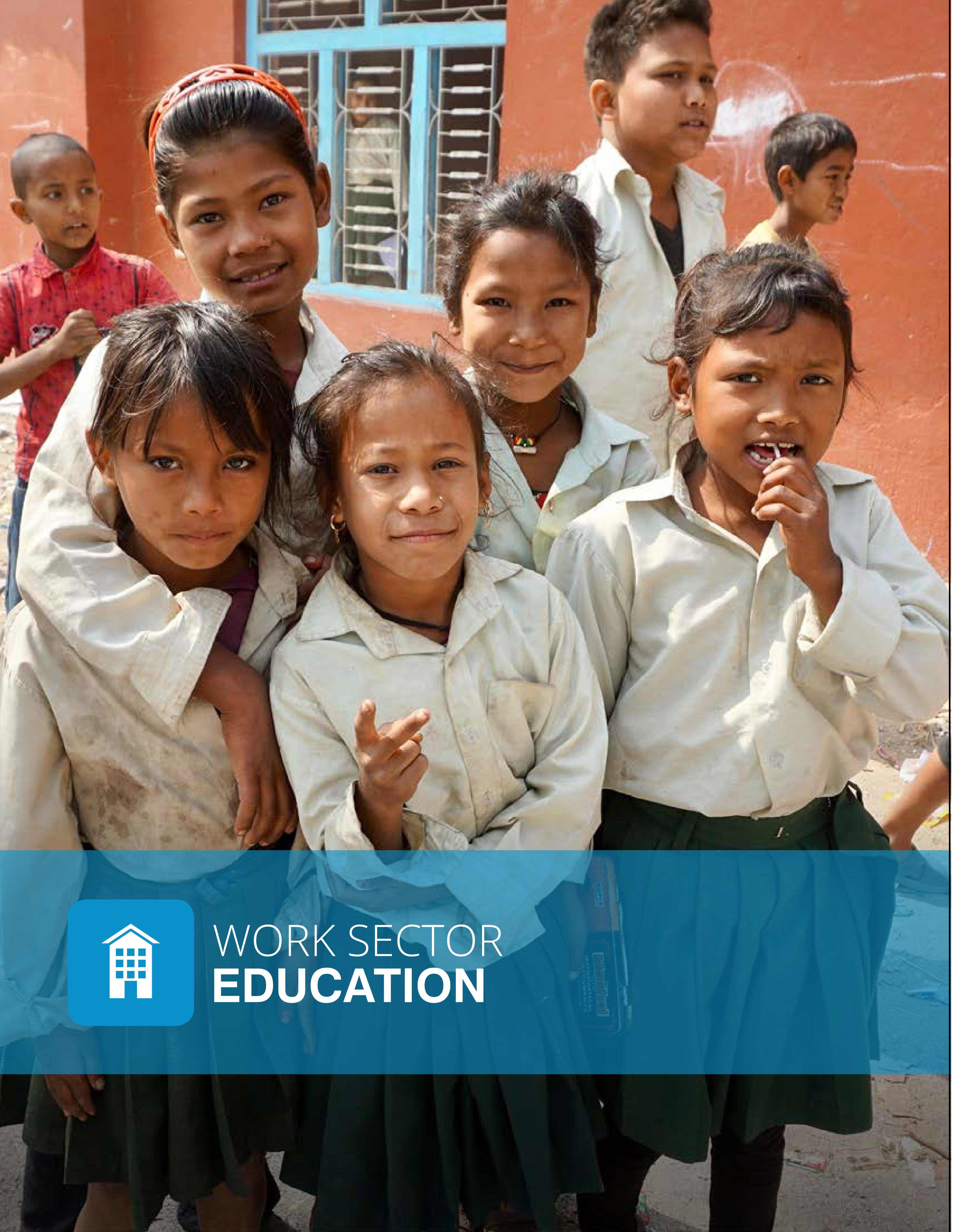
Miyamoto has extensive experience providing construction supervision services, quality control and quality assurance (QA/QC) in the most challenging environments. We carried out large-scale construction supervision and construction quality-control programs after major international disasters, such as the 2010 Haiti earthquake and the 2015 Nepal earthquake.

Many buildings fail in earthquakes due to lack of quality control and oversight during their construction. These services need to be provided by a strong team of locally trained engineers. Quality-control plans developed must identify milestones during construction when the quality of construction materials and construction practices are tested and monitored. Our field and job-site experience also shows that inadequate supervision can lead to schedule and budget overruns.

Miyamoto has developed construction-supervision tools and methods that can be implemented in remote areas or challenging environments, such as in the aftermath of disasters or politically and socially unstable conditions. We have trained thousands of local engineers around the globe in proper construction supervision. This capacity and skills remains in country for generations, leading to improved construction practices long after projects are completed.

Miyamoto also serves in a project and construction management role, and has successfully overseen the safe building or rebuilding of schools and homes.

> "We have trained thousands of engineers in proper construction supervision."



EDUCATION

School buildings in many developing countries are structurally deficient, putting students in harm's way

In many developing countries, school buildings are structurally deficient in construction, leading to irrevocable collapse or severe damage when earthquakes and other natural disasters strike. This has resulted in the tragic loss of thousands of children's lives. In some cases, no public school buildings exist and students learn in tents or other makeshift classrooms in the open. In disaster-prone nations in particular, safe school buildings are critical for the protection of a nation's most valuable asset – its children, and to realize long-term benefits, such as a reduction in poverty, economic prosperity and greater social and political stability. Getting school children back into schools is also the prime indicator to measure a nation's post-disaster recovery efforts and, hence, its disaster resilience.

Miyamoto International strives for safety in all schools across the world. Miyamoto's team of engineers and experts have successfully completed a range of education-related projects. One type of project that is key in decreasing lives lost in the event of an earthquake is seismic risk identification and mitigation. Miyamoto has a long history of completed multi-hazard vulnerability assessments and prioritization methodologies for schools so the most vulnerable can be made safer and more resilient. From these types of projects, new guidelines for seismic retrofitting are often developed and implemented, improving the safety of future school buildings.

All across the world, Miyamoto has provided structural engineering expertise to governments, international organizations and humanitarian partners to repair and seismically strengthen school buildings in post-disaster environments. In post-earthquake Nepal and Haiti, Miyamoto was particularly active in providing engineering services to repair and retrofit damaged schools. In rural Haiti in 2015, Miyamoto was the engineer behind 15 new public school buildings being built of steel construction with resilient designs that — having withstood the strong winds of recent hurricane seasons — are now widely recognized as examples of resilient school construction.

To increase local capacity and ensure sustainability, training of national engineers is key for any sector of disaster risk reduction. Miyamoto has successfully trained government staffs of engineers and professionals across developing countries, providing skilled labor training in structural assessments, design, construction supervision and quality control.

Fonds d'Assistance Economique et Sociale (FAES) – 19 Schools Project

LOCATION:
Multiple Locations, Haiti

YEAR:
2013

CLIENT:
Fonds d'Assistance Economique et Sociale (FAES)

PROJECT TEAM:
BJ Architects
Aedefica
IDCO
Tecina

CONSTRUCTION COST:
$11 Million

SCALE:
19 Campuses

This Inter-American Development Bank (IDB) funded projected implemented with FAES is an ambitious project consisting of the construction and retrofit of 19 campuses across Haiti. We provided site visits to all of the retrofit sites to document existing status and conditions, while providing contractor and skilled labor (mason) training and periodic construction supervision. Some complexities included the retrofit of schools at various levels of construction ranging from about 20% to 75% complete, remote locations throughout Haiti, different building types and materials and collaboration with multiple architects. Miyamoto is the Engineer of Record designing per the International Building Code, 2009 edition.

ADB Earthquake Emergency Assistance Project

LOCATION:
8 earthquake affected districts in Nepal: Kathmandu, Bhaktapur, Okhaldhunga, Ramechhap, Sindhupalchok, Kavrepalanchok, Dolakha and Sindhuli

YEAR:
September 2018

CLIENT:
Government of Nepal, Asian Development Bank

CONSTRUCTION COST:
$12.3 Million

SCALE:
142 Schools

The Asian Development Bank (ADB) is supporting the Government of Nepal's Earthquake Emergency Assistance Project (EEAP) with the approval of a $200-million-dollar loan. The EEAP project was committed to helping Nepal recover from the April 2015 earthquake by responding to the devastating earthquake damage with the rebuilding of schools, roads and government buildings. The aim of the project was to strengthen these buildings and roads so they are safe for use and to provide resilience in the case of future disasters.

Miyamoto served as a design and supervision consultant for the EEAP by providing the structural engineering expertise and technical assistance necessary for the reconstruction of 142 schools. For the first 100 schools, Miyamoto's role in the project included structural assessments of existing schools and development of designs according to necessary disaster-resilient standards and for the additional 42 schools, Miyamoto's role included structural assessment works only. With the conclusion of the Earthquake Emergency Assistance Project, thousands of children will be able to return to their classrooms and continue their education in a safe environment.

Rapid Vulnerability Assessment of Earthquake Affected School Buildings

LOCATION:
Aceh, Indonesia

YEAR:
2017

CLIENT:
The World Bank

SCALE:
246 school buildings

Miyamoto conducted a seismic vulnerability assessment of 246 school buildings in Aceh, Indonesia following the 2016 Pidie Jaya earthquake. Current school building engineering, construction practices and techniques were found to be relatively unchanged over the past 40 years. The assessment found that a simplified prioritization for building strengthening was feasible and simplified strengthening of the existing buildings is achievable. Field survey data was collected for 246 school buildings to divide buildings into similar construction types, for which fragility functions and fatality ratios for each damage state were prepared. Probabilistic analysis was conducted to estimate fatalities. The overall fatality rate for the school buildings was about 1.2 percent, resulting in the anticipated loss of 180 lives. The 25 (10 percent) worst-performing school buildings would contribute to 25 percent of fatalities. It is imperative that action be taken to reduce the risk to the lives of schoolchildren. Miyamoto also recommended design standards for future design and construction.

Case Study

Disaster-Resilient School in Haiti Survives Hurricane Matthew

OVERVIEW

In very remote villages, there is very little to no infrastructure. Schools become the center for communities. If built per international standards, these schools can serve as critical shelters in emergency conditions such as hurricanes and earthquakes.

In Haiti, a program funded by the United Nations Children's Fund (UNICEF) was implemented to construct 15 school campuses in rural, remote communities. These communities were so remote that, in some cases, were only reachable by foot. Miyamoto's role was to assist Haiti's Ministry of Education and UNICEF by designing a school building prototype that would be cost effective to build in the most remote settings, but would meet quality standards so the structures would not crumble in a disaster.

THE PROGRAM

The goal of the program was to improve access to education for rural children in Haiti. In Haiti's most rural communities, nearly one child in three does not attend school. Lack of access, lack of secure school facilities and the poor quality of education were the top contributing factors children's non-attendance.

Eight and seven new school buildings were to be built in the rural southern and northern part, respectively, of the island nation. Many of the classrooms at these schools were previously built with temporary materials, including pieces of tent, plywood and corrugated iron. For the new school prototype, the remoteness of the sites posed a unique set of challenges for decisions on design, best building materials and ensuring construction quality, essential for disaster resilience.

TECHNICAL ASPECTS

Miyamoto designed a prototype to build 15 schools in Haiti. A steel structural system was primarily selected due to the remote nature of the school locations. Many of the schools were accessible by dirt road, but some of the sites were only accessible by foot, with the most remote site, Cinai, being a four-hour walk from the nearest vehicular access.

In the design process, considerations were made for various geotechnical and site-specific criteria, including wind and seismic design parameters. The resulting design was adaptable to each site based on regulatory standards, site topography and architectural requirements. Further, in the design process, it was necessary to provide options in the structural drawings as multiple contractors would be building the different schools.

Miyamoto also was responsible for providing comprehensive construction-management services and ensuring quality assurance/quality control (QA/QC) during construction. The QA/QC process had to be adaptable to accommodate the variety of sites. Full-time sight supervision and regular multi-layered QA/QC checks that included visits from senior engineers and structural design team members provided near real-time information transfer between the design intent and the contractor. ThIs resulted in more efficient project completion and quality of workmanship. The traditional QA/QC model involves checks at key points of construction, but can result in repetition of a mistake that requires lengthy and potentially costly corrections. The general contractor is much more receptive to QA comments when there is a minimal impact on work flow versus significant rework.

The approach of standardized buildings distributed over multiple locations was very efficient and facilitated the bidding process. If each site would have had only two unique buildings it would necessitate the design of 30 separate buildings; in this approach, structural design and construction observation was simplified. Further, by breaking the project into groups that were geographically similar, the contractors were able to garner efficiencies by location and from the repetition.

RESULTS

As a result of the diligence applied in the design and implementation process, as well as QA/QC, the UNICEF schools located in the affected departments of the South have successfully withstood the recent hurricanes, including Hurricane Matthew. Hurricane Matthew caused widespread damage, which left more than 170,000 people in rural Haiti seeking shelter. While many of the houses and infrastructure in the southern department were flattened, the UNICEF-funded Catiche school, located on a hillside, withstood the storm with only very minor roof damage. The structure provided immediate safety and shelter to the community throughout the storm.

Location of UNICEF Schools in the North

Location of UNICEF Schools in the South

IN THE MIDST OF HURRICANE MATTHEW, SCHOOL PROVIDES SHELTER

On October 4, 2016, Hurricane Matthew, a Category 4 hurricane, struck southwestern Haiti. Hurricane Matthew was the strongest storm to land in Haiti since 1964, and it caused more than 175,000 people to seek refuge in shelters; more than 450,000 children were out of school. As school buildings are often disproportionately affected structures in a disaster, officials looked to those schools that withstood Hurricane Matthew for best practices in construction.

One such school was the school in Catiche, built as a part of the UNICEF-funded program. Miyamoto’s role was to assist Haiti’s Ministry of Education and UNICEF by designing a school building prototype that would be cost-effectively constructible in the most remote settings while also meeting quality standards so the structures would not crumble in a disaster.

The Catiche school sits on a hillside in a remote part of the Southern Department. The area was battered during Hurricane Matthew and while most other structures in the area were damaged or destroyed, this structure had very little to no damage, providing immediate shelter to the community in this rural village. It also emphasized the importance of investing in resilient infrastructure.

HEALTH CARE

Miyamoto's diverse health care portfolio illustrates how to best ready hospitals to serve communities in crisis

Post-disaster, hospitals are critical lifelines for those injured and in need of medical care. A major concern with many of the hospitals in environments prone to hurricanes and earthquakes is their resiliency. Hospitals are often built incrementally and expanded upon over time. This makes hospitals more vulnerable. Aging infrastructure also contributes to the fragility of these important buildings. Finally, many hospitals are at or near full occupancy; if these buildings are not resilient, the gap to recovery is worsened.

Miyamoto International has done extensive international work to safeguard hospitals. Miyamoto worked to help introduce one of the most advanced seismic technologies, base isolation, to Turkey, becoming the government's seismic expert on this high-performance technology. In Costa Rica, Miyamoto conducted an earthquake risk assessment for 59 hospital buildings. The goal was to identify the most critical and seismically vulnerable hospital buildings using a fatality-based prioritization methodology. This assessment allows government funds to be appropriately allocated for maximum impact. Miyamoto innovatively applies this type of cost-benefit analysis in disaster-prone environments to ensure efficient and effective solutions.

Other Miyamoto projects related to health care are multifaceted and include the review of current building standards in order to update or develop seismic rehabilitation and retrofit standards for health care infrastructure. We also conduct capacity building and knowledge sharing sessions with government engineers and other technical experts, continuing their goals of increasing local capabilities. Miyamoto engineers and experts lead pilot studies for the retrofit and rehabilitation designs of high-priority hospitals to serve as precedents or examples for future health care retrofits.

> "Hospitals are critical lifelines for the injured post-disaster and must be resilient."

Seismic Risk Mitigation and Rehabilitation of 2,000 Schools and Hospitals, Istanbul, Turkey

LOCATION:
Istanbul, Turkey

YEAR:
2007–2012

CONSTRUCTION COST:
$1 Billion

SCALE:
2,000 Structures

DONORS
World Bank, European Union Funded

Miyamoto provided engineering quality control for World Bank and the European Union (EU) funded seismic risk-mitigation project in Istanbul, involving more than 2,000 structures. Several hundred schools, hospitals, and emergency operation centers were seismically strengthened. With Turkish engineers and academicians, we developed a guideline for seismic rehabilitation by using the latest US, Japanese and Turkish codes. By working with the Turkish government, we were able to assist with high-performance earthquake engineering, providing designs that achieve superior performance at reduced costs. Our international culture helped us to work effectively with local and other international consultants.

Hôpital d l'Universite d'Etat d'Haiti (HUEH)

LOCATION:
Port-au-Prince, Haiti

YEAR:
2018

CONSTRUCTION COST:
$83 Million

SCALE:
270,000 SF

Miyamoto International's scope on the 270,000-SF Hôpital d l'Universite d'Etat d'Haiti (HUEH) was structural design for the hospital's 10 buildings, as well as structural observation and construction administration through the duration of structural work. Our design using structural steel with buckling restrained braces (BRBs) resulted in more than $1 million in savings. Challenges included working on a landlocked site while the existing, earthquake-damaged hospital remained operational. The new, multidisciplinary hospital provides 534 inpatient beds with services to include maternity, gynecology, obstetrics, pediatrics and emergency services in a highly technical environment. The finished complex will serve countless Haitians throughout the region and was a cooperative effort between hospitals and practitioners from the French West Indies, CHU Pointe à Pitre, CHU de Fort de France, Assistance Publique Hôpitaux de Marseille and Necker Institute Pediatrics in Haiti.

AFFORDABLE HOUSING

Housing developments for vulnerable, at-risk communities must be both affordable and resilient

In partnership with public officials and in collaboration with international agencies and donors, Miyamoto has designed housing developments for disaster-prone and vulnerable communities that are affordable yet built to international standards. Miyamoto's experience in housing ranges from designing and supervising the construction of new homes both in urban and remote rural villages, as well as designing effective home repairs and retrofitting pre- and post-disaster.

Many of Miyamoto's housing projects also focus on building the technical capacity of local engineers and masons. Improving local construction practices in the informal construction sector can improve the resiliency of even the most marginalized communities. Often times it is the small changes in structural detailing and building practices that can make a big difference.

While effectively reducing risk to life and injury, successful home rebuilding or retrofitting solutions need to be both affordable and easily replicable. Miyamoto's approach is focused on using local construction materials and practices with correct detailing. Rebuilding or retrofit solutions are only effective if they can be easily and cost-effectively implemented by local masons.

In the aftermath of the 2010 Haiti earthquake, Miyamoto designed repair guidelines that led to the repair and structural upgrade of more than 12,000 damaged (yellow-tagged) houses. Through remittance, many homeowners began repairing their own houses using Miyamoto's guidelines and replicating the construction work carried out under the multi-donor-funded home repair and retrofit program. Today, the seismic detailing of residential houses in these poor neighborhoods has significantly improved from the prevailing pre-earthquake construction practices.

Miyamoto's programmatic approach follows a national-international partnership model. Miyamoto's national team of engineers and experts work with international earthquake engineers to develop seismic retrofit solutions. As a corollary to such an approach, solutions uniquely fit the local context while being in accordance with global engineering best practices and lessons learned from global earthquake disasters and international home-retrofit programs. National-international collaborations yield more applicable, replicable, affordable and innovative solutions.

Miyamoto has also worked with finance institutions to develop incentives and provide access to credit for house improvements and retrofits, and rent-to-own housing schemes.

Cabaret Housing Project

LOCATION:
Cabaret, Haiti

YEAR:
2013

CLIENT:
USAID
CEMEX Haiti

CONSTRUCTION COST:
$6 Million

SCALE:
156 Houses
32 Square Meters per House

This residential development in the coastal town of Cabaret, Haiti included the construction of 156 individual, reinforced concrete houses. Each house was constructed using a proprietary reusable form system. The houses were built as one-story buildings, but were engineered to allow the addition of a second level later. Miyamoto is the Engineer of Record for all the houses. Miyamoto provided structural engineering and quality-assurance services (for house construction only). The design was per the International Building Code, 2009 Edition.

Repair of 12,000 Earthquake-Damaged Homes in Haiti

LOCATION:
Port-au-Prince and Leogane, Haiti

YEAR:
2012

CLIENT:
United States Agency for International Development (USAID), World Bank, Caterpillar Foundation, Clinton-Bush Haiti Fund, American Red Cross

COST:
$25 Million

SCALE:
12,000 Houses

AWARDS:
ENGINEERING NEWS RECORD "BEST GLOBAL PROJECT," 2014

Hundreds of thousands of people died in the 2010 Haiti earthquake for the simple reason that the buildings were built poorly. To ensure that the same mistakes would not be repeated, Miyamoto International worked closely with the Ministry of Public Works and its partners to develop and publish guidelines on how buildings could be properly repaired. Miyamoto International and its partners then trained 5,000 masons and dozens of contractors in these improved construction techniques. With funding from USAID, the World Bank, the Caterpillar Foundation, the Clinton-Bush Haiti Fund and the American Red Cross, we then repaired more than 12,000 houses. Between the published manual, the classroom trainings and a rigorous quality-control program during construction, Miyamoto International and its partners were able to improve the quality of the construction in Haiti and help ensure that future earthquakes will be far less deadly.

Chhulemu Village Reconstruction

LOCATION:
Chhulemu, Nepal

YEAR:
2015

CLIENT:
Himalayan Development Foundation (HDF)

SCALE:
30 homes and a school

More than 600,000 houses in rural Nepal partially or totally collapsed as a result of the 2015 earthquakes. Located in the lower Mount Everest region, the village of Chhulemu also was badly hit. About one-third of the village houses needed to be demolished due to sustaining extensive earthquake damage. Repairs and retrofits are required for all of the remaining homes. The Himalayan Development Foundation (HDF), in partnership with Miyamoto, has taken on the task of rebuilding the Chhulemu village. Miyamoto designed rural house construction and repair guidelines per national code, which is being used by a local team of carpenters and HDF volunteers to reconstruct and repair the damaged homes. Miyamoto is providing technical advice and guidance, as well as ensuring that quality construction is maintained as part of a full-time QA/QC program. Chhulemu is a day's hike away from the nearest road and home to 30 families that are largely subsistence farmers.

CULTURAL HERITAGE PRESERVATION

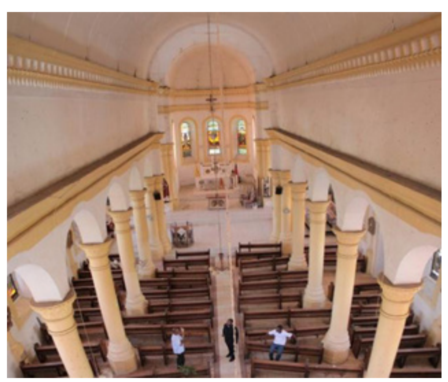
Miyamoto's restoration and retrofit solutions are constructible, innovative and address the local context

Highly specialized engineering expertise is required to retrofit cultural heritage and historic buildings. This is an area of expertise which Miyamoto is proud to be a world leader. Miyamoto works to develop state-of-the-art wind and seismic strengthening measures by remedying the shortcomings of outdated engineering and construction practices while also preserving and/or reconstructing the architectural heritage or significant buildings.

From ancient cathedrals in Italy and Haiti and 1930s and '50s iconic theme buildings in Los Angeles, to historic palaces and Buddhist temples in Nepal, Miyamoto has built a strong reputation for finding restoration and retrofit solutions that meet the unique local context and challenges and are constructible and innovative while conforming to the country's historic building preservation guidelines and practices.

Miyamoto has addressed structural weaknesses of these buildings both pre- and post-disaster, setting global best practices and helping to preserve these buildings for generations to come.

"We save historic structures while preserving the architectural heritage of significant and iconic buildings."



Miragoane Cathedral

LOCATION:
Miragoane, Haiti

YEAR:
2015

CLIENT:
Boulder Associates

CONSTRUCTION COST:
$2.8 Million

SCALE:
7,125 SF (662 Square Meters)

Miragoane Cathedral is an historic building of great importance to Haitians. To protect this heritage building originally constructed in the 1880s, Miyamoto provided a high-performance seismic rehabilitation and retrofit using base isolation. The building was originally constructed of rock and mortar, but is now supported by 54 triple-pendulum base isolators to protect it in a major seismic event.

The base isolators “float” the building so its columns, arches and walls won’t be rocked in an earthquake. In conjunction with these isolators, a 12-inch moat around the building was constructed to accommodate movement. Base isolation is a modern technique that is being applied to ancient structures — a collaboration that saves the old with new technology.

Seismic Restoration, Repair of Gaddi Baithak

LOCATION:
Kathmandu, Nepal

YEAR:
2017-2018

CLIENT:
Department of Archaeology, Ministry of Culture, Tourism and Aviation, Government of Nepal

DONOR::
U.S. State Department, U.S Embassy Nepal through the U.S. Ambassadors Fund for Cultural Preservation

IMPLEMENTING PARTNER::
Miyamoto Global Disaster Relief

PROJECT PARTNERS:
UNESCO
Pachali Bhairab and Manakamana Niram Sewa, contractors

COST:
$700,000

SCALE:
35,000 SF, two stories

Miyamoto seismic experts in Nepal, Italy and the U.S. collaborated on engineering solutions after a 7.8 magnitude earthquake in 2015 severely damaged the Gaddi Baithak, a 100-year-old heritage palace at the UNESCO World Heritage site in Durbar Square. The scope included evaluating the damage and developing a technical plan to repair and seismically strengthen the building while also preserving its architectural significance using traditional materials/methods. The team also oversaw construction and facilitated ongoing coordination with government ministries and agencies, historic experts and other key stakeholders. The reconstruction effort–a model for defining engineering practices and methods for repairing such buildings in Nepal rather than demolishing them post-earthquake–is a world-class example of stakeholders working together for the goal of accurate, well-built reconstruction of important heritage buildings. The ambassadors fund generously funded the entire project. Miyamoto provided in-kind services.

Repair, Seismic Retrofit and Supervision of Thrangu Tara Abbey

LOCATION:
Kathmandu, Nepal

YEAR:
2018

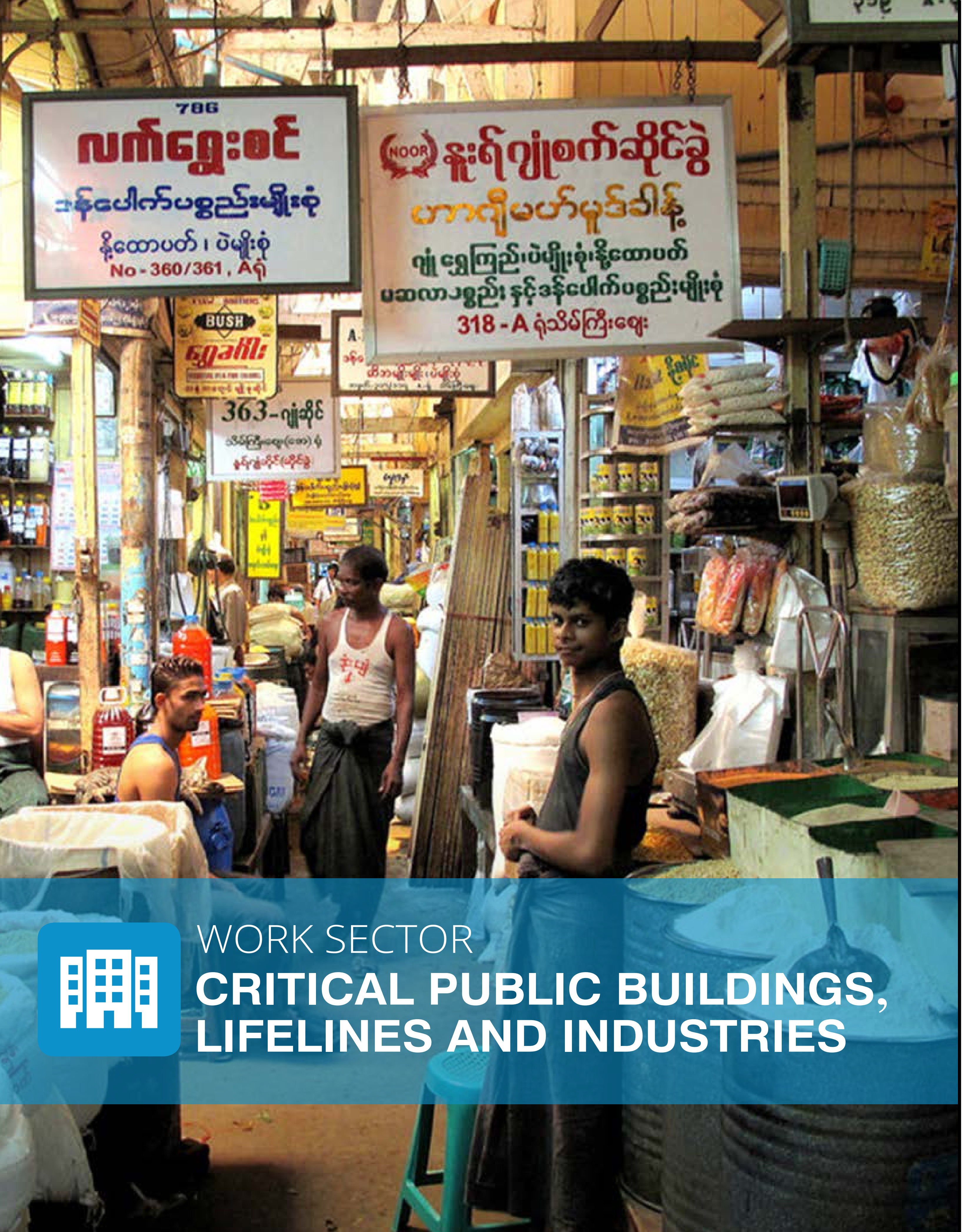
CLIENT:
Namo Buddha Buddhist Meditation and Education Center

SCALE:
Monastery and Two Surrounding Hostel Blocks

The Thrangu Tara Abbey Monastery for Buddhist nuns is located in Swayambunath, a very special spiritual place that is home to the famous Swayambu Stupa and many monasteries and temples.

The monastery and two surrounding hostel blocks were not originally built according to proper standards, resulting in significant damage from the April 2015 earthquake.

Miyamoto conducted a detailed structural assessment of the building to develop a solution that would allow for the preservation of the unique and important architectural features of the monastery. Miyamoto's retrofit design included column concrete jacketing and shear walls to ensure that the monastery would exceed seismic standards and be safe for re-entry. A haunched beam was also implemented to protect the sacred Buddha within the monastery from being damaged in the case of a future earthquake.



WORK SECTOR
CRITICAL PUBLIC BUILDINGS, LIFELINES AND INDUSTRIES

CRITICAL PUBLIC BUILDINGS, LIFELINES AND INDUSTRIES

Miyamoto works to mitigate vulnerabilties in public infrastructure to support a city's or nation's resiliency

Miyamoto International has worked across the globe to protect key buildings, utilities and lifelines prior to disasters to reduce the loss of life, mitigate against economic loss and unnecessary downtime and sustain industries.

For example, the government of Myanmar and the World Bank contacted Miyamoto to identify vulnerable structures and determine the cost and scope associated with follow-up disaster risk reduction work. The goal was to reduce the risk of injury in the event of an earthquake with a major focus on public markets. Daily, thousands of people gather at these markets, making them among the most densely populated public spaces in Yangon, along with being critical places of trade. Assessing the vulnerability of vital, densely populated facilities is extremely important in preparing for an earthquake.

To support a city or nation's path to resiliency, Miyamoto works in a variety of sectors, addressing vulnerabilities in public infrastructure including bridges, public utilities, water-distribution networks and airports. Public infrastructure is important for transportation, health and aid, but building it up is an enormous cost. Mitigating against the risk of an earthquake is more cost-effective than rebuilding infrastructure post-disaster.

Critical industries vary from country to country. While the garment industry is key in Bangladesh, tourism defines the GPD in Nepal. Miyamoto seeks to strategically identify industries critical for the prosperity of the people and nations, and help protect these through targeted, highly strategic and systematic risk mitigation programs.

> "Mitigation is clearly more cost-effective than rebuilding post-disaster."

Rapid Vulnerability Assessment and Prioritization of Critical Public Facilities

LOCATION:
Republic of Myanmar

YEAR:
2017

CLIENT:
World Bank

Miyamoto International was commissioned by the World Bank to assist local strategies by conducting a rapid vulnerability assessment of public buildings in Yangon, including schools, hospitals, cultural heritage buildings and other public facilities. Engineers are working with local stakeholders to identify vulnerable structures and determine the cost and scope associated with a follow-up DRR project. The objective of assessing and then retrofitting vulnerable structures is to reduce the risk of injury and death in a design-level earthquake. Retrofit solutions produced will take into account local construction strategies and materials. The project began with a focus on large public markets because of the lives at risk in the antiquated buildings. Myanmar is highly vulnerable to the impact of natural disasters, ranking second on the global climate-risk index and experiences an earthquake of magnitude 5 or greater on the average of four times annually.

Delhi Airport ATC Tower

LOCATION:
New Delhi, India

YEAR:
2015

CLIENT:
Delhi Airport

CONSTRUCTION COST:
$50 Million

SCALE:
101.9 Meters Tall

The new ATC tower at Indira Gandhi International Airport is unique in more ways than one and has already become an icon for the people in Delhi. It stands 101.9 meters tall with a slenderness ratio of nearly 1:14. It is the first project in India to have a Tuned Mass Damper, which is positioned at approximately 91 meters high. What makes the Delhi ATC the most unique in the world is that it has a constantly changing shape as it rises from the ground all the way to the roof. While the tower outline moves inwards along the X-direction, it simultaneously moves outwards in the Y-direction. The top two levels of the tower are steel; the rest of the tower is built using high-strength reinforced concrete. The tower rests on a raft 3.0 meters deep and is supported by 32 piles 1.5 meters in diameter thick. A glass lift located at the center of the tower provides a 360-degree view of the Delhi skyline. The design team was responsible for the entire design and also post-contract services.

The Finger Building at Otopeni International Airport

Located in a seismically active area of Bucharest, The Finger Building is a new terminal at the Otopeni International Airport. This structure uses a sophisticated combination of 3,500-tons of steel and concrete bracing walls. Covering the upper level are undulating box section girders that span 41 meters and are supported by tubular volutes resting on solid steel columns. Precise works prefabrication for large components permitted completion of the entire structure in less than four months. The building's white paint provides a calm and friendly atmosphere at a busy location. The project earned the ECCS Steel Design award in 2011.

LOCATION:
Bucharest, Romania

YEAR:
2010

CLIENT:
Technital S.P.A.

GENERAL CONTRACTOR:
Romairport SRL (Astaldi Group)

GENERAL DESIGN:
Technital S.P.A.

CONSULTANT FOR STRUCTURAL DESIGN:
Ing. Boerio, Miyamoto International, Milan

CONSTRUCTION COST:
60 Million €

SCALE:
17,000 Square Meters

AWARDS:
EUROPEAN STEEL DESIGN AWARDS 2011

Bob Hope Airport, Emergency Response Center

Within the scope of the Regional Intermodal Transportation Center, Miyamoto International was responsible for designing an Emergency Response Center (ERC), which is housed within the three-level, 520,000 SF structure. The center was built to remain elastic during an 8.0 magnitude earthquake, providing a safe location for regional emergency operations. In the event of such a cataclysmic temblor, Bob Hope Airport is designed to become a hub for flying in, storing and distributing emergency supplies. With "seismic isolators" built like shock absorbers into its roughly 130 columns, each floor was designed to "roll" 30 inches from side to side without damaging the building. Miyamoto was specifically chosen for this project for our unmatched expertise in seismic engineering and our command of innovative technologies.

LOCATION:
Burbank, CA

YEAR:
2015

CLIENT:
Burbank-Glendale-Pasadena Airport Authority (Owner)
PGAL (Prime)

Case Study

Helping Nepal's Tourism Industry Recover: Post-Earthquake Assessment of Nepal's Most Popular Trekking Toutes in the Everest and Annapurna Region

OVERVIEW

Forty percent of Nepal's GDP comes from tourism. The country is home to Mount Everest and the Himalayas and around the world, the mountainous country has become a popular destination for trekking. Following the powerful earthquakes of April and May 2015, the extent and severity of earthquake-related structural and geotechnical damage in the two main trekking regions, Everest and Annapurna, remained unknown. Nepal's Ministry of Tourism received mixed reports from the field, leaving them unable to advise Embassies and tour operators whether the country would open for tourism for the next trekking season in October of that year.

On behalf of the Government of Nepal's Ministry of Culture, Tourism and Civil Aviation, with funding from SAMARTH-NMDP, a program supported by UKAID, and the World Bank's IFC, an assessment team was dispatched from June 25 to July 2, 2015 to the Annapurna and Everest region to observe and record seismic damages along the main trekking routes as a result of the earthquakes. This case study will focus on the damage assessment of the Annapurna Region as the most popular tourism trekking route in the country.

THE PROGRAM

The objective of the rapid reconnaissance of the region was to: a) develop a baseline understanding of the extent of earthquake-related damage, b) advise on the overall trekking safety of the region's routes and c) provide recommendations on repairs or risk mitigation that informed tourism recovery and commercial readiness strategies that were then being developed by the government, its international development partners and Nepal's tourism industry at large. The aim of these efforts was to promote tourism back to Nepal and support the nation's economic recovery.

TECHNICAL ASPECTS

A mix of helicopter flyover and trekking was used to access and assess the Annapurna region. The assessment began at Pokhara; from there 31 villages and approximately 220 km of trails were assessed. The majority of the trail was assessed by helicopter and most of the structures were on foot.

The methodology applied to conduct the structural damage assessment was a rapid visual assessment per ATC-20 damage-assessment methodology and Department of Urban Development and Building Construction (DUDBC) guidelines.

In the Annapurna region, the team assessed approximately 30 bridges and 30 villages, which included a total of approximately 250 accommodations. The team also conducted a visual reconnaissance of the areas of concern for potential geologic hazards such as rock fall, landslides, debris flows and other related steep terrain hazards to rapidly assess earthquake-related geologic damage and risk in the region.

A team of structural and geotechnical engineers experienced in post-disaster damage and risk assessments, together with Intrepid Travel, a local tourism group that is deeply familiar with the region, formed the field assessment team. A videographer also joined the team to film the terrain from the helicopter. This footage was later studied to further verify site conditions.

RESULTS

The results of the Annapurna region assessments included earthquake damage observed at six of the accommodation structures out of 250. The bridge assessments did not indicate any structural earthquake damage.

Overall, there was very little damage in the Annapurna region; only 3 percent of accommodation buildings had damage making repairs cost effective. Further, the Annapurna Circuit and Annapurna Sanctuary trails and villages assessed appear largely undamaged by landslides following the April and May 2015 earthquakes.

Some areas did not show evidence of recent failure but had particularly high hazard levels due to their existing features or geometry, for example, very high rock slopes and areas with evidence of historic large rock fall and slope instability.

A range of recommendations came out of the assessment. It was recommended that risks be managed using the As Low As Reasonably Practical (ALARP) Principle. The focus was on finding a number of relatively low-cost measures to effectively reduce the risk to occupants and tourists in this area. They included increasing signage, such as ‘Landslide Hazard, No Stopping for 2 km’ to alert of a heightened chance of future landslide failure while encouraging trekkers to walk through the area without stopping to reduce the track occupancy time in the area. Similarly, signage for rock fall hazards in targeted areas were encouraged. Hazard areas should be signed and communicated to both locals and visitors to initiating a communication program and include meetings, radio broadcasts and signage/posters.

It was also recommended that frequently used tracks should be checked for new failures and rock fall following monsoon rains each year. Similarly, bridges on the tracks also checked every year during floods and after flood waters recede to look for damage or undermining from river scour and erosion.

INTERNATIONAL DEVELOPMENT + HUMANITARIAN ASSISTANCE

WORK SECTOR
SUSTAINABILITY AND GREEN BUILDINGS

SUSTAINABILITY AND GREEN BUILDINGS

Developing countries should and can utilize "green" practices to cost-effectively build sustainable buildings and cities

Green buildings focus on the fact that the design, construction and operation of a building can reduce negative impacts to the environment and people, save energy and water, decrease carbon emissions and even strengthen local communities and create jobs. Approaching infrastructure through the lens of environmental sustainability, social impact and resource efficiency throughout the design, construction, operation, maintenance and beyond are central to advancing smart and resilient infrastructure worldwide. Green buildings that take into account this combination of engineering and sustainability have the power to make cities both safer and more resilient. Miyamoto provides structural engineering services with a view toward sustainability: the design of durable and functional buildings using renewable material resources. Our sustainable expertise includes structural services for more than 20 LEED projects as well as a half dozen Net Zero Energy projects.

Recently, Miyamoto was the expert structural consultant for the Architectural Nexus office in Sacramento, the first ever Living Building Challenge building in California and the first Adaptive-Reuse "Living Building" in the world. The building uses recycled rainwater as its water supply and solar panels generate all of its energy. The lack of solar exposure in the winter and rain in the summer exemplifies that this technology can be applied around the world to improve quality of life and reduce waste.

Sustainability is important in developing countries as well. Following the 2010 earthquake in Haiti, the country's fragility led to an increased demand for stronger, more secure structures that were also built with consideration for the environment and access to affordable energy in circumstances where the power grid is often unreliable. Miyamoto was a critical part of the design and construction team that built the William Jefferson Clinton Children's Center, a LEED Platinum certified building that is "net zero."

> "Buildings can impact the environment in positive ways."

William Jefferson Clinton Children's Center

LEED Platinum and Net Zero Energy anticipated

LOCATION:
Port-au-Prince, Haiti

YEAR:
2018

CLIENT:
United States Green Building Council

CONSTRUCTION COST:
TBD

SCALE:
6,000 SF

Miyamoto is the engineer of record for the new William Jefferson Clinton Children's Center in Port-au-Prince which replaces an orphanage severely damaged in the 2010 earthquake. The engineering focuses on achieving Net Zero Energy and LEED Platinum certification for the center. The concept of sustainable design is new to Haiti and allows the structure to gain independence from the city's unreliable power grid. The L-shaped structure surrounds a central courtyard and contains a ground-level "safe zone" where occupants can gather in the event of an earthquake. Since day one structural safety has been the basis of design and this building exceeds the code requirements by utilizing lightweight infill and an increased seismic load to provide enhanced seismic performance. Other unique net-zero design features include a closed-loop water system collecting, treating and storing water on-site and a bamboo "boundary layer" protecting the exterior walkways from direct sunlight while allowing for daylighting and natural ventilation.

miyamoto. RELIEF

nonprofit engineering experts

> Miyamoto Global Disaster Relief is the only nonprofit structural engineering organization in the world promoting resiliency by retrofitting seismically dangerous schools and providing technical expertise before, during and after a disaster. Our mission is to save thousands of lives through state-of-the-art engineering in communities in need.

Our work emphasizes building and retrofitting schools in developing countries. This is particularly important in countries where the potential lack of advanced engineering knowledge is critical for the life safety of the community.

The Engineering News Record recently awarded Miyamoto Relief a "Global Best Projects" awards for its 2014 seismic retrofit/renovation of a 1,500-student school in what many call Port-au-Prince, Haiti's most challenged neighborhood, Cite Soleil. The projects chosen for the award are selected as "exciting examples of the challenges, risks and rewards of designing and constructing throughout the world." That's exactly what Miyamoto Global Disaster Relief's mission calls on us to do.

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Case Study

Rebuilding Post-Earthquake Haiti's Lycée National de Cite Soleil: From Community Tensions to Shared Goals to Collective Results

OVERVIEW

In the densely populated commune of Cite Soleil, located in a commune in the Port-au-Prince area of Haiti, cycles of violence, particularly manifested through armed gangs and extreme poverty, have long plagued the daily lives of its 300,000+ residents.

In addition to a lack of personal security and economic opportunities, access to education has also long been a challenge. When the January 2010 earthquake devastated Port-au-Prince and surrounding areas, damaging or collapsing more than 200,000 structures, the secondary school, the Lycée National de Cite Soleil, was so badly damaged, it was unusable.

THE PROGRAM

Given the complexity of the operating environment prior to the 2010 Haitian earthquake and the widespread devastation that followed the earthquake, the best approach for engaging in community-level reconstruction activities was with heightened contextual awareness and a deep understanding of local needs, capabilities and formal and informal networks. A number of previous humanitarian interventions in Cite Soleil were not completed because of the intense challenges faced working in the commune, which led to the community's widespread mistrust of foreign assistance.

To engage in the retrofitting and rehabilitation of the schooll, Miyamoto Global Disaster Relief utilized the following principals to guide the design and implementation process, similar to what can be applied and adapted in a post-conflict setting:

- **Community-led reconstruction:** Residents of Cite Soleil and other local Haitian businesses and organizations contributed time, labor and effort to collectively advance the work of the project. Miyamoto engineers and technical experts provided oversight and international knowledge, as well as global best practices, to build back better and safer. All efforts were grounded in and driven by the local community
- **Neutrality:** At its core, the retrofit and rehabilitation project was a technical exercise that addressed shared community goals and interests. Given the history of the community for armed tension, this was a collective project based on a neutral, technical platform that enabled groups that would not otherwise work together peacefully to advance a common goal.
- **Investing in Resilience:** As is widely recognized, resilience is multi-dimensional. The project was not just about the built environment but how this key public structure interrelated with the community and the broader building back better efforts with support from the Haitian Ministry of Education.
- **Impartiality:** The project was based on addressing a core need: education.
- **Flexibility and Adaptability:** Because the focus of the project was small-scale and invested heavily in community level buy-in and participatory processes, implementation was able to be adjusted to meet community level realities.
- **High Impact:** From start to finish, the project delivered internationally recognized results rapidly with high community-level impact.

In areas plagued by violence and intra-community tensions, the need to apply innovative, community-led solutions to identify, advance and ultimately reach a common goal is critical. Using the approach outlined above laid the foundation for sustainability and stability at a critical time for the community's history.

photo credit above: Marie Elizabeth Arago

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RESULTS

These efforts in Cite Soleil have made a lasting impression. The Lycée National de Cite Soleil school continues to thrive and a new community-led initiative already has momentum and seed funding: the building of the Cite Soleil library. To date, the community has raised more than $80,000 USD for the library; Miyamoto Relief will donate $50,000 USD and provide its structural engineering expertise. Built on the collective success of the school, diverse stakeholders are once again coming together to build the second largest library in all of Haiti to further advance access to educational materials to Cite Soleil's youth. Technical knowledge transfer has the ability to change the way communities in conflict interact with each other and can strengthen the foundation for a better future.

photo credits: Marie Elizabeth Arago

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Utilizing Technical Experience in Post-Conflict Programming

Miyamoto's work in urban disaster risk reduction and its technical leadership work to strengthen post-conflict programming:

- Focus on localization and community-led reconstruction
- Utilizing a technical project or training as neutral ground for parties to come together and work on a common goal
- Interventions can be small-scale and flexible to adapt to rapidly changing environments
- Projects can be high-impact, with delivery and results in a short period of time

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