


# Performance of Public Buildings and Critical Facilities

## Mitigation Assessment Team Summary Report and Recommendations

Commonwealth of the Northern Mariana Islands

Super Typhoon Yutu

P-2179

July 2021

FEMA

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# 1. Executive Summary

In October 2018, Super Typhoon Yutu broke several records by becoming the strongest typhoon ever recorded to impact the Commonwealth of the Northern Mariana Islands (CNMI). Yutu killed two people and injured 133 more, while also destroying homes and damaging infrastructure throughout the populated areas. Many commercial and public buildings in southern Saipan had roof coverings blown off their roof decks. For residential buildings, the damage was more extensive, with roof coverings and roof decks being removed from roof frames or the loss of the entire roof structure. Multi-story concrete and steel frame buildings generally performed well, though some of these buildings experienced heavy roof covering and cladding (wall, door, and window) damage, with only a few of these buildings being considered destroyed. Many buildings that did not have extensive, visible exterior damage were observed to have experienced significant water intrusion, causing damage throughout building interiors. Vegetation was uprooted and mixed with other wind-borne debris, such as doors and storm shutters, contributing to the wind damage. Saipan's and Tinian's critical infrastructure—including hospitals, schools, airports, power, water supply, and roadways—all suffered major damage. The damage caused by Typhoon Yutu is not unique, but rather something that the CNMI will likely face again in the future.

In November 2020, FEMA's Building Science Branch, in conjunction with FEMA Region 9 and supported by the Strategic Alliance for Risk Reduction (STARR II), provided specialized architectural and engineering expertise through the Mitigation Assessment Team (MAT) program to assess building performance; develop customized Recovery Advisories and Fact Sheets; provide tailored training and subject matter expertise; and document observations, conclusions, and recommendations. These products and trainings are meant to support the CNMI in ongoing recovery from Super Typhoon Yutu and in preparedness for and resiliency in the face of future similar storms.

The team worked with local agencies to assess damage to many types of buildings, including the hospital, police and fire stations, schools, government offices, and homes. The goal was to learn how buildings performed during the typhoon and why they withstood or did not withstand the strain caused by wind and flood hazards. Upon conclusion of the field investigation, specialists worked as a team to analyze the field data, as well as other damage reports and studies conducted by government agencies or private firms. Finally, the team prepared conclusions and developed recommendations based on these findings. This information is presented in three targeted reports:

- Codes, Standards, and Permitting (FEMA P-2177)
- Performance of One- and Two-Family Dwellings (FEMA P-2178)
- Performance of Public Buildings and Critical Facilities (FEMA P-2179)

This report (FEMA P-2179) focuses on the performance of the public buildings and critical facilities impacted by the event. This summary report is technical in nature and intended for an audience of building/facility owners, engineers, and design professionals. The recommendations resulting from building performance and forensic assessments help FEMA coordinate with agencies and organizations to assess the hazard-resistant provisions of building codes and standards. In addition, recommendations support community development of long-term strategies to reduce future damage and impacts from hazard events and improve community resilience.

The recommendations are provided to help the CNMI outline a path forward for reconstruction, building community resilience, and other relevant ongoing activities. The CNMI can use these recommendations to help guide and better prepare the government agencies, property owners, and other stakeholders in the community for future storms. Table 1 briefly summarizes the detailed recommendations found in Section 4 of this document and recommends a leader to implement each suggested action.

**Public Assistance Program and Policy Guide**

(FEMA PAPPG, 2020)

According to the *PAPPG*, additional grant funding may be available for eligible repairs to provide hazard mitigation against future events. For more information, see the *PAPPG,* Appendix J.

**Table 1: MAT Summary of Recommendations**

| # | Recommendation | Leader for Implementation |
|---|---|---|
| SITE ISSUES | | |
| 1 | Establish the top of the lowest floor at least 1 foot above the highest adjacent grade. The building pad should be raised, and the surrounding ground should be sloped away on all sides. | Building/Facility Owner |
| GENERAL BUILDING ISSUES | | |
| 2 | Perform vulnerability assessments focused on the building envelope (roof system, exterior walls, glazing, doors, etc.), structural elements, and building systems. | Building/Facility Owner |
| 3 | Design mechanical penthouses, equipment housing, doors for rooftop access points, and equipment rooms to resist high winds. Properly maintain weather gaskets and seals as a part of an entire system. | Building/Facility Owner |
| 4 | Implement permanent mitigation measures to address building vulnerabilities, reduce risk, and improve overall building performance. | Building/Facility Owner |
| 5 | Make corrosion repairs and mitigation a priority and a part of regular maintenance programs. Create and use building maintenance programs for all buildings. | Building/Facility Owner |
| 6 | Upgrade all the airport passenger boarding bridges to withstand wind loads based on the latest building codes and using recently developed topographic wind speed maps. | Airport Facility Owners |
| 7 | Properly elevate and protect school water pumps and use proper electrical service. | School Building Owners |

| # | Recommendation | Leader for Implementation |
|---|---|---|
| ROOF SYSTEM ISSUES | | |
| 8 | Design and install new and replacement roof systems for critical facilities to resist high wind pressures and accommodate wind-borne debris. | Building/Facility Owner |
| 9 | Consider permanent repairs when repairing a roof, as well as mitigation using FEMA's Public Assistance Program 406 recommendations for roofs. | Building/Facility Owner |
| 10 | Regularly assess, adequately maintain, and repair or replace roofs when needed. | Building/Facility Owner |
| WINDOWS, DOORS, AND OPENING PROTECTION SYSTEMS | | |
| 11 | Use only sectional or rolling doors that have been tested and rated for wind loads and debris impact associated with the design criteria for the specific site. | Building/Facility Owner |
| 12 | Check shutters regularly and make sure that they are properly maintained. | Building/Facility Owner |
| 13a | Label glazing systems (windows and doors) for code-compliant pressure ratings and impact resistance ratings. | Building/Facility Owner |
| 13b | Consider constructing vestibules with two sets of doors at main entry points. | Building/Facility Owner |
| 13c | Ensure that designers, building and facility owners, and other property managers are aware that the building code requirements for the protection of glazed openings for critical facilities are different than for other categories of buildings. | Building Safety Code Division (BSCD) |
| GENERAL BUILDING SYSTEMS | | |
| 14 | Design and install roof-mounted equipment to adequately resist being displaced by design-level wind speeds for the given location. | Building/Facility Owner |
| 15 | Install lightning protection systems with mechanically fastened or fully adhered connectors to secure conductors and air terminals to resist high-wind loads. | Building/Facility Owner |
| 16a | Create a program to standardize materials. Island systems need to be common, simple, modular, and swappable. | Building/Facility Owner |
| 16b | Create a Capital Improvement Plan with five-year projections to better schedule maintenance and upgrades and secure proper funding. | Building/Facility Owner |

| # | Recommendation | Leader for Implementation |
|---|---|---|
| **LIFE SAFETY AND EMERGENCY POWER SYSTEMS** | | |
| 17 | Size generators for each specific site based on building code requirements. | Building/Facility Owner |
| 18 | Decommission mechanical systems after their service mission is complete, i.e., remove after an event. Develop a maintenance schedule to service equipment at the manufacturer's recommended interval during operation. | Building/Facility Owner |
| 19 | Refuge areas should have multiple access and egress points. | BSCD, Building/Facility Owner |
| 20 | Complete repairs to life-safety equipment in compliance with local codes prior to building re-occupancy. Use dedicated or redundant surge protection equipment on fire alarm panels. | BSCD, Building/Facility Owner |
| **EMERGENCY SHELTERS VERSUS SAFE ROOMS AND STORM SHELTERS** | | |
| 21a | Consider a local amendment to the CNMI building code to require that storm shelters be designed to ICC 500® standards for select educational and first responder facilities. | CNMI Legislature |
| 21b | Design and construct new school facilities to include bathrooms and rated doors to comply with ICC 500 storm shelter standards. | CNMI Office of Homeland Security & Emergency Management (HS&EM) and CNMI Public School System (PSS) |
| 22 | Establish a program for safe rooms and storms shelters across the CNMI that provides consistent criteria and standards for the facilities being designed for life-safety protection using FEMA 361 criteria and the ICC 500 requirements. | HS&EM |
| 23 | Develop a "best available refuge area" (BARA) assessment program to evaluate existing buildings for BARA use before, during, and after storm events. | CNMI HS&EM, Department of Public Works (DPW), PSS |

# 2. Acronyms and Abbreviations

| | |
|---|---|
| ASCE | American Society of Civil Engineers |
| BARA | Best Available Refuge Area |
| CHC | Commonwealth Health Center |
| CNMI | Commonwealth of the Northern Mariana Islands |
| DPW | Department of Public Works |
| EOC | Emergency Operations Center |
| FEMA | Federal Emergency Management Agency |
| HS&EM | CNMI Office of Homeland Security & Emergency Management |
| HVAC | Heating, Ventilation and Air Conditioning |
| ICC | International Code Council |
| MAT | Mitigation Assessment Team |
| MBS | Metal Building System |
| MEP | Mechanical, Electrical and Plumbing |
| mph | Miles per hour |
| MWFRS | Main Wind Force Resisting System |
| NFPA | National Fire Protection Association |
| NRCA | National Roofing Contractors Association |
| PAPPG | Public Assistance Program and Policy Guide |
| PSS | Public School System |
| SEI | Structural Engineering Institute |
| UPS | Uninterruptible Power Supply |

# 3. Event Description and Purpose of Study

In October 2018, Super Typhoon Yutu broke several records by becoming the strongest typhoon ever recorded to impact the Commonwealth of the Northern Mariana Islands (CNMI), the most powerful tropical cyclone of 2018 worldwide, and the strongest storm to hit the United States since 1935. For this commonwealth situated far from the continental U.S., evacuation is not a viable option. Help and supplies cannot reach the area for days following major storms. It is important to understand the event and the purpose of this study, as it serves to help the CNMI make sound decisions for disaster preparedness and recovery to best protect its citizens against future storms.

## 3.1. Event Description

Super Typhoon Yutu began as a tropical depression in the Pacific Ocean and grew rapidly in a short period of time, producing 90 mile-per-hour (mph) winds on October 23, 2018, that doubled the next day to 180 mph (Figure 1). On October 25, 2018, Yutu made landfall in the CNMI, with maximum sustained winds of 180 mph and torrential rainfall, according to the U.S. Navy Joint Typhoon Warning Center.[1]

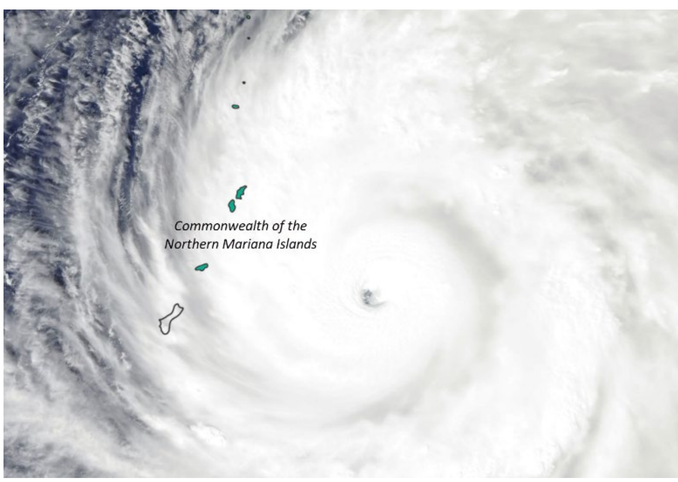


**Figure 1. Super Typhoon Yutu crossed over CNMI in October 2018. [Image credit: NASA].**

Yutu killed two people and injured 133 more, while also destroying homes and infrastructure throughout the populated areas. Most commercial and public buildings in southern Saipan had roof coverings blown off their roof decks. For residential buildings, the damage was more extensive, with roof coverings and roof decks being removed from roof frames or the loss of the entire roof structure. Multi-story concrete and steel frame buildings generally performed well, though some of these buildings experienced heavy roof covering and cladding (wall, door, and window) damage; only a few of these types of buildings were considered destroyed. Many buildings that did not have extensive, visible exterior damage were observed to have experienced significant water intrusion, causing damage throughout building interiors. Vegetation was uprooted and mixed with other air-borne debris, such as doors and storm shutters, contributing to the wind damage. Saipan and

[1] Wind speed reference data obtained from https://weather.com/storms/typhoon/news/2018-10-28-super-typhoon-yutu-philippines-china-saipan

Tinian's critical infrastructure—including schools, airports, power, water supply, and roadways—all suffered major damage.

## 3.2. Purpose of this Study

In 2020, FEMA's Building Science Branch, in conjunction with FEMA Region 9 and supported by the Strategic Alliance for Risk Reduction (STARR II), was asked to engage the Mitigation Assessment Team (MAT) to study building performance in support of long-term recovery efforts in the CNMI. Though the MAT typically deploys immediately following a major disaster, providing support even two years after Super Typhoon Yutu can help steer long-term recovery and resilience efforts for these high-risk islands.

In November 2020, the MAT deployed to Saipan and Tinian to assess building performance; develop customized Recovery Advisories and Fact Sheets; provide tailored training and subject matter expertise; and document observations, conclusions, and recommendations. The team worked with local agencies to assess damage to many types of buildings, including the hospital, police and fire stations, schools, government offices, and homes. The goal was to learn how buildings performed during the typhoon and why they withstood, or did not withstand, the strain caused by wind and flood hazards. Upon conclusion of the field investigation, specialists worked as a team to analyze the field data, as well as other damage reports and studies conducted by government agencies or private firms. Finally, the team prepared conclusions and developed recommendations based on these findings.

This report (FEMA P-2179) focuses on the performance of the public buildings and critical facilities impacted by the event. This summary report is technical in nature and intended for an audience of building/facility owners, engineers, and design professionals. The recommendations are provided to help the CNMI outline a path forward for reconstruction, building community resilience, and other relevant ongoing activities. The CNMI can use these recommendations to help guide and better prepare communities, property owners, and other stakeholders for future storms and encourage them to take specific actions, where possible.

The likelihood of having a Yutu-type storm impact the CNMI has always existed, and the threat remains. Storms like Typhoon Soudelor and Super Typhoon Yutu have served as demonstrations of the need to take the proper steps to be prepared when the next disaster occurs.

**Public Assistance (PA)/Section 406 Mitigation Best Practices**

FEMA disaster declarations that provide Public Assistance (PA) program resources to restore public buildings to their pre-disaster condition allow for cost-effective mitigation to improve the damaged elements of public buildings in accordance with Appendix J of the *Public Assistance Program and Policy Guide* (PAPPG). Where applicable, this report includes recommendations from the PAPPG to encourage best practices in future mitigation efforts.

# 4. Observations, Conclusions, and Recommendations

## 4.1. Site Issues

CNMI's Smart Safe Growth Guidance (SSG) provides visualization tools and recommends assessing current flood extents. Learn more and access SSG support materials at https://opd.gov.mp/.

Managing site conditions around a building—including physical, geophysical, climatic, ecological, environmental, and geotechnical considerations—is a primary method to reduce building damage from hazards. It also helps alleviate potential site access concerns, since access roads themselves can flood and landscaping features such as trees and shade structures can dislodge and block access roads. Surface water runoff and drainage features such as culverts and swales need to be kept in working condition to move water away from buildings. A properly sited building has interior floor elevations higher than the surrounding ground so that water from surface runoff and other sources runs away from the building instead of into it. Failure to construct buildings to a sufficiently high elevation relative to the surrounding property or failure to maintain shallow swales can lead to water entering buildings and disrupting operations. Proper design, construction, and maintenance of site drainage is important to protect buildings from stormwater intrusion.

### 4.1.1. OBSERVATIONS

The MAT observed site drainage flooding in schools, hospitals, fire stations, and the Emergency Operations Center (EOC). Water observed inside these facilities came from ground surface runoff or from roof runoff that was not directed away from the buildings.

At schools, the MAT noted water came in through doors as it flowed from areas of high ground toward lower ground, where buildings such as cafeterias were located. The cafeterias were used as refuge areas during the storm, and some had standing water 1 inch to 3 inches deep while occupants slept on cots inside (Figure 2).

**Figure 2: Tinian Elementary School Cafeteria, where surface runoff flowed across the ground and into the building (red arrow), which was used as a refuge.**

At the EOC, water emerged from under the slab-to-wall interface in interior rooms with no exterior door openings. The ground surface and groundwater outside the building was higher than the interior and the slab-to-wall interface was not watertight. Additionally, the water's flow path followed a narrow space between the emergency generator and the building. The water from the EOC roof, the generator roof, and the sloping terrain behind the EOC was constrained to flow through this narrow area that was originally designed as a shallow swale. The red arrow in Figure 3 indicates the area of constriction and the higher grade.

**Figure 3: The architectural reveal along the side of the EOC (yellow building) is approximately 1 to 2 feet above the interior finished floor. The narrow area where drainage flows is indicated by a red arrow.**

At the Tinian Fire Station and the Tinian Hospital (Figure 4), a surface water conveyance had become filled with debris as a result of a lack of maintenance, blocking the flow of water between the buildings. This caused water to flow above ground across the driveways that served the emergency room access doors. The runoff also overwhelmed the sanitary drains and septic fields, causing water to upwell through a service port located in front of the emergency room entrance.

**Figure 4: Left—Culvert between Tinian Fire Station and Hospital blocked by accumulated soil. Right—Hospital Emergency Entrance with canopy where surface water flowed. Design conveyance swale has filled in (red line).**

### 4.1.2. CONCLUSIONS AND RECOMMENDATIONS

#### Conclusion 1

Site conditions are not managed effectively, especially surface runoff water systems. Buildings with the main or first-floor level at or near the adjacent grade are vulnerable to localized flood damage and this often was the case. Existing site drainage systems would benefit from regular maintenance.

> ***Recommendation 1:***
>
> For new construction and reconstruction, building and facility owners should establish the top of the lowest floor at least 1 foot above the highest adjacent grade. The building pad should be raised, and the surrounding ground should be sloped away on all sides. For existing construction, regrade sites and install drainage swales (conveyances) to direct water away from the building. Once good site drainage is established, regularly maintain existing drainage infrastructure.

"Green infrastructure" interventions such as rain gardens or green roofing also may reduce stormwater burdens and flooding risk during a high-volume rain event. More recommendations about rain gardens in the CNMI can be found at https://dcrm.gov.mp/cnmi-rain-garden-manual-2/.

## 4.2. General Building Issues

Refer to FEMA P-2177, *Codes, Standards, and Permitting,* for observations, conclusions, and recommendations for CNMI building codes and standards, permitting, and code enforcement.

The MAT observed public buildings and critical facilities that included reinforced concrete-framed and steel-framed buildings, both with concrete roof decks. Also observed were low-rise buildings (typically three stories or less) with a variety of roof decks, roof structural systems, and load-bearing wall systems. The buildings with reinforced concrete roof decks performed well, with damage and impacts limited to their roof coverings and openings (including shutter systems). Many buildings that had roof decks other than reinforced concrete were observed to have wind damage or failure of the roof deck, with the roof deck even separating from the supporting frame or structures, and roof covering damage. In these instances, this damage was commonly observed along roof edges and ridges.

Building elements that included wind bracing and major structural components, equipment anchoring systems, and water pumps also were observed by the MAT. Many of these elements were deteriorating or improperly designed or installed prior to the event, making them more vulnerable to damage from high winds and wind-driven rain. At several locations, rooftop equipment was no longer anchored due to corrosion of the tie-downs. Poor or no maintenance left building components weakened, compromised, or not effectively supported.

Many facilities were dependent on water pumps, but these pumps were not located in buildings or areas protected from wind-borne debris or above local flooding. Rather, they were housed in metal building systems (MBSs) with damage to many Main Wind Force Resisting System (MWFRS) elements, such as anchor bolts and base plates. In some, MBS frame elements were deteriorated beyond their serviceable life.

### 4.2.1. OBSERVATIONS

MBSs performed at differing levels, depending on the age and condition of the building and components. Several MBSs had initial design features that led to degradation of important elements, including lack of building pads under column bases, which caused corrosion of anchor bolts and base plates. The building pads frequently were very low, thus exacerbating the problem by allowing water to accumulate and stand at the important load transfer interface at the column base (Figure 5).

**Figure 5: Left—MBS showing displaced wall. Right—Column (red arrow) at displaced wall showing corrosion of column base plate (blue arrow) and lack of housekeeping pad. Also, the building pad elevation is at grade, aggravating conditions.**

MBSs that were newer and less deteriorated in condition seemed to perform better, further indicating that corrosion was a main cause of performance issues. Some MBSs had wind bracing that was undersized or past its service life. MBSs also had a problem with water intruding into plastic-wrapped blanket insulation layers. The plastic held the water and provided a favorable environment for organic growth (Figure 6).

**Figure 6: MBS plastic-wrapped blanket insulation showing organic growth due to inability to remove water from interior layers of insulation.**

The MAT observed rooftop equipment penthouses, elevator equipment rooms, and stairwells to the roof that failed, allowing rain into the buildings. Frequently, these failures were a result of door gaskets, seals, and latches that did not perform as needed. During the years leading up to when Yutu hit, temporary and emergency repairs to rooftop equipment and openings had been made but did not prevent rainwater from entering and damaging the building and contents.

Poor maintenance resulted in building components that had reduced capacity compared to when they were placed into service. The effects could be seen in the anchorages of rooftop equipment, where anchors were severed at corrosion points (Figure 7). This lack of proper anchorage leaves rooftop equipment vulnerable to blowing off, creating a direct opening in the roof to rainfall entry during a storm.

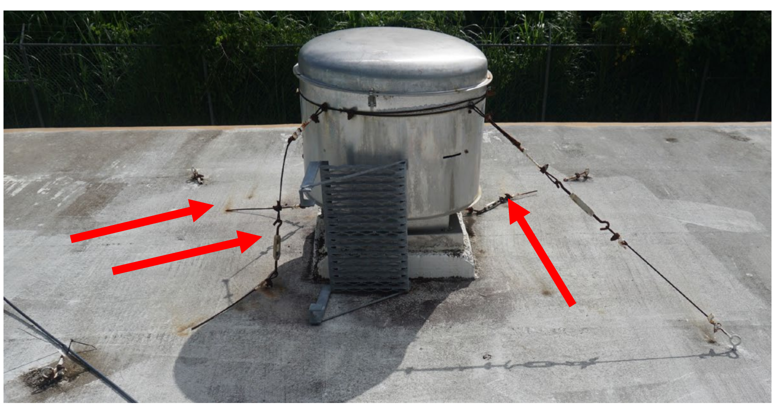

**Figure 7: Rooftop fan unit where three of four cable anchors failed because of corrosion (red arrows).**

Several school complexes had water pumps for non-potable functions that were not in secure and weather-tight enclosures. The pumps were subject to debris and weathering that degraded the pump life and service. The electrical outlets that were observed in use in the pump enclosures were not appropriate for wet weather use, but instead were made for dry interior use (Figure 8).

**Figure 8: School water pump in building enclosure that did not provide adequate weather protection.**

The Saipan Airport suffered damage to the movable aircraft passenger boarding bridges that allow passengers to embark and disembark aircraft directly to the upper level of the terminal. The passenger boarding bridges have storm moorings that lock them into place, preventing damaging movement. During Super Typhoon Yutu, the storm moorings failed, allowing several passenger boarding bridges to swivel and move with the extreme winds, damaging the terminal building and the passenger boarding bridges (Figure 9). The MAT observed new storm moorings at several locations are already being installed at several passenger boarding bridge locations to address this issue.

**Figure 9: View of damaged passenger boarding bridge location. Original storm mooring foundations are painted yellow (left side).**

Termite damage and decay were seen in buildings with wooden trusses and frames. Schools that had wooden trusses for roof framing had catastrophic losses when the compromised trusses failed to provide the necessary strength to resist storm winds, resulting in complete loss of the roof (Figure 10).

**Figure 10: Left—School with compromised wooden roof trusses that caused the entire roof structure to be blown away by high winds. Right—Same school roof trusses revealing termite damage that weakened the roof-to-wall anchorage.**

### 4.2.2. CONCLUSIONS AND RECOMMENDATIONS

#### Conclusion 2

Some building owners have a limited awareness of or ability to mitigate typhoon hazard risks and vulnerabilities. This applied to both building components and building systems.

> ***Recommendation 2:***
>
> Building and facility owners should perform vulnerability assessments using FEMA P-2062, *Guidelines for Wind Vulnerability Assessments of Existing Critical Facilities,* focusing on the building envelope (roofing, exterior walls, glazing, doors, etc.), structural elements, and building systems.

#### Conclusion 3

Equipment penthouses, elevator equipment vents on roofs, and doors to these roof structures (as well as stairwells) failed, allowing rain to enter buildings.

> ***Recommendation 3:***
>
> Building and facility owners should design mechanical penthouses and equipment housing to resist high winds. Design doors for rooftop access points and equipment rooms to resist high winds. Properly maintain weather gaskets and seals as a part of an entire system.

#### Conclusion 4

Guidance is needed for post-disaster emergency repairs to exterior building cladding (roof, wall, window, and door systems) to reduce additional damage. Emergency/temporary repairs to rooftop mechanical openings did not prevent or limit additional damage to some facilities.

### *Recommendation 4:*

Building and facility owners should implement permanent mitigation measures to address building vulnerabilities and manage risk. Opportunities exist for eligible building and facility owners to obtain federal funding for many types of mitigation projects. FEMA's *Public Assistance Program and Policy Guide* (PAPPG), Appendix J, lists mitigation measures that FEMA considers to be cost effective through the public assistance program. FEMA also provides other opportunities for project funding through several Hazard Mitigation Assistance (HMA) programs.

FEMA Public Assistance considers a project to be cost effective when the mitigation measure does not exceed 15% of the total eligible repair cost of the existing facility for which the mitigation measure applies, or if the building/facility owner can demonstrate that it is cost effective through an acceptable benefit-cost analysis methodology.

## Conclusion 5

Building maintenance is not occurring or is not being performed effectively. This is leading to significant corrosion of metal systems (structural and cladding) that weakens buildings or that results in avoidable damage. Building maintenance schedules are key tools to improve building performance and ensure continued operation of a building both during and after a storm event.

### *Recommendation 5:*

Repair, replacement, and mitigation of corroded structural and cladding elements should be a priority for all building owners and operators and be part of regular maintenance programs. Building and facility owners should create and use building maintenance programs for all buildings. The CNMI could identify a lead agency to create a template for use in all public buildings.

## Conclusion 6

The airport passenger boarding bridges have vulnerabilities to high winds. The wind loads acting on the passenger boarding bridges appeared to overload the pedestal foundations and anchor rods as well as the high wind tie-downs.

### *Recommendation 6:*

The airport should consider upgrading and retrofitting all the passenger boarding bridges to withstand the wind loads based on the latest building codes and using the recently developed 2020 FEMA CNMI Special Wind Region maps with topographic wind speed-up effects for Saipan. These designs need to include the passenger boarding bridge pedestal foundations as well as the tie-downs. Additionally, any seals, openings, and glazing also should meet wind load and debris impact requirements.

### Conclusion 7

Schools that have water pumps located in non-elevated and non-weather-protected spaces are vulnerable to damage and function loss. Use of non-wet service electrical components in wet service environments is a severe hazard. Loss of these systems can result in a building being unfit for occupancy after a storm event.

***Recommendation 7:***

School water pumps should be in a weather-tight enclosure or space that is properly elevated and protected from wind loads and wind-borne debris. If the enclosure is not weather resistant, use appropriately rated electrical services.

## 4.3. Roof Systems

Roof systems serve as the first line of defense for the top surface of buildings by keeping wind, rain, and wind-borne debris from entering through the roof. Historically, damage to roof coverings is the leading cause of building performance problems in high-wind events.[2] Roof coverings also are the most commonly damaged building element.[3] The failure of a roof system on a building can lead to substantial water damage to interior spaces and contents. The proper design, installation, and maintenance of roof systems serves a key role in keeping the building occupants, components, systems, and contents protected during storms. CNMI MAT Fact Sheet 1: *Maintenance for Roof Coverings, Windows/Doors, Shutters, and Exterior Building Elements* provides additional information on this topic.

The National Roofing Contractors Association (NRCA) Roofing Manual includes the following definitions:

**Roof Assembly:** An assembly of interacting roof components, including the roof deck, air or vapor retarder (if present), insulation, and membrane or primary roof covering designed to weatherproof a structure.

**Roof Covering:** The exterior roof cover or skin of the roof assembly consisting of membrane, panels, sheets, shingles, tiles, etc.

**Roof System:** A system of interacting roof components generally consisting of a membrane or primary roof covering and roof insulation (not including the roof deck) designed to weatherproof and sometimes improve the building's thermal resistance.

### 4.3.1. OBSERVATIONS

Common types of roof coverings in the CNMI for public buildings and critical and essential facilities include membranes, metal panels, and tile roofs. The MAT observed that the design and installation of wind-resistant roof coverings often was inadequate. A large number of roof coverings at schools and critical facilities failed, resulting in a significant

[2] FEMA 543, *Design Guide for Improving Critical Facility Safety from Flooding and High Winds* (2007).

[3] FEMA P-2062, *Guidelines for Wind Vulnerability Assessments of Existing Critical Facilities (2019).*

reduction or complete loss of functionality to buildings. When roof coverings did remain in place, many roofs were punctured by wind-borne debris, including those on public and commercial buildings. The roof punctures allowed rain to enter buildings and cause more damage to the contents.

Most roof coverings can be penetrated by debris with only moderate momentum. Having a secondary membrane and sufficient insulation/coverboard is critical for absorbing debris energy and successfully keeping debris from reaching the secondary membrane—as discussed in FEMA P-424, *Design Guide for Improving School Safety in Earthquakes, Floods, and High Winds.*

Membrane roofs at some schools delaminated, not only along ridges at high wind pressure zones, but also in the field of the roof. Failures observed included all aspects of roofs, from roof flashing through the different roof covering elements and associated attachment methods. Many of these issues resulted in water intrusion with damage to the interior components. At the Tinian Fire Station, most of the electrical conduits, switchboards, and panels were inundated by water coming from roof leaks.

A number of metal panel roof coverings (mostly at schools, but also at other public buildings) were only lightly secured and did not use adequate numbers and types of fasteners (Figure 12). While some roof coverings remained in place during the storm, many roofs experienced partial or complete roof covering blow-off. Many metal roof panels were attached to wood purlins with nails, which provide inadequate wind uplift resistance (Figure 12). Nails should never be used to secure metal roof panels to the structure. Screws provide a much stronger connection to resist wind uplift and are much less susceptible to dynamic loading.

**Figure 11: Left—Wind damage to metal roof with inadequate numbers and size of fasteners, Marianas High School in Saipan; Right—Closer view showing the metal roof pulled through the head of the fastener with the fastener head no longer visible.**

**Figure 12: Left—Wind damage to Hopwood Middle School in Saipan; Right—Inadequate fasteners, such as nails, led to much of the damage. [Image credit: Forrest Lanning, FEMA]**

Tile roofs exhibited poor performance from the high winds of Super Typhoon Yutu. At the Office of Aging building, the corrosion of tile fasteners significantly contributed to failure (Figure 13). When these roof coverings fail during high-wind events, they become wind-borne debris. The blow-off of one roofing element can lead to the failure of others and can result in a large portion of the roof being lost.

**Figure 13: Left—Tile roof damaged by strong winds at the Office of Aging; Right—Corrosion of fasteners contributed to the failure.**

Maintenance of roof coverings often was inadequate. Liquid applied roof coverings on concrete roof decks—such as at Commonwealth Health Center (CHC), at the main Saipan Airport concourse buildings, and at Fire Station 2—were not adequately maintained. The lack of maintenance led to roof membrane failure and water intrusion. Some roofs failed because fasteners became corroded and were unable to resist wind uplift. Other roofs suffered from water intrusion through the roof covering, and then through the roof decks to the building interiors, which caused additional damage to the building components.

### 4.3.2. CONCLUSIONS AND RECOMMENDATIONS

#### Conclusion 8

Design and installation of wind-resistant roof coverings often was inadequate. Although the MAT observed examples of good roof covering performance, the number of roof covering failures at schools and critical facilities was notable and resulted in a significant impact to or complete loss of functionality of the buildings.

***Recommendation 8:***

Building and facility owners should identify roof coverings that are vulnerable to high winds and design and install new and replacement roof coverings for public buildings and critical facilities to withstand the wind loads and accommodate wind-borne debris based on the latest building codes and using the recently developed 2020 FEMA CNMI Special Wind Region maps with topographic wind speed-up effects for Saipan. Regardless of the type of roof covering that is installed, the fasteners and connectors used to secure the roof covering must be installed at appropriate spacing and frequency (i.e., with more fasteners or stronger elements) along the roof perimeter, corners, and ridges.

When repairing the roof, consider permanent repairs using FEMA's Public Assistance Program 406 recommendations:

1. Install anchors, fasteners, and connectors that are compatible with the roof system and are highly corrosion-resistant (consider stainless steel connectors).
2. Strengthen the high-wind pressure areas of roof decks and roof covering systems (e.g., corner zones, roof soffits, overhangs).
3. Strengthen or protect roof openings, such as hatches and skylights.

#### Conclusion 9

Much of the damage to public buildings and critical facilities was due to the failure of roof coverings. Improperly installed roof coverings, or roof coverings lacking appropriate fasteners, caused the failure of roof coverings, leading to water intrusion into buildings.

***Recommendation 9:***

Roof coverings being repaired or replaced should comply with the latest edition of the building code and use the new island-specific wind speed maps that incorporate wind speed-up effects provided in the 2020 FEMA CNMI Special Wind Region maps. Screws, not nails, should be selected as roof covering fasteners. All fasteners should be corrosion resistant. See FEMA P-424, *Design Guide for Improving School Safety in Earthquakes, Floods, and High Winds,* and FEMA 543, *Design Guide for Improving Critical Facility Safety from Flooding and High Winds,* for guidance and design techniques.

### Conclusion 10

Many of the schools and public buildings had roof coverings that were inadequately maintained or were past their useful service life. When impacted by the storms, these roof coverings failed even though the roof decks supporting them did not. Much of the damage and loss of function at schools, health centers, and critical facilities could have been limited or avoided if roof coverings were properly maintained and replaced prior to the end of their effective service life.

> ***Recommendation 10:***
>
> Building and facility owners should regularly assess, adequately maintain, and repair or replace roof coverings when needed. Building owners and operators should develop maintenance programs for their building exteriors, specifically for roof coverings. The maintenance programs should include a section to address punctures of the roof coverings for when roof coverings remain in place but are damaged.

## 4.4. Windows, Doors, and Opening Protection Systems

Windows and doors frequently were the source of building performance problems and failures during Super Typhoon Yutu. Openings must be able to withstand both the pressure from winds and the impact from wind-borne debris. The glazing in doors should meet the requirements for debris impact resistance—see FEMA publication P-424, *Design Guide for Improving School Safety in Earthquakes, Floods, and High Winds,* for a discussion on protection of glazing in doors. Common approaches to managing wind loads and wind-borne debris are to have pressure-rated windows and doors to withstand the wind forces and to have protective systems to handle the debris. When impact-rated glazing, such as laminated glass or polycarbonate, is used, shutters are not required. Proper design, testing, installation, and maintenance of these opening protection systems are vital to overall building performance.

### 4.4.1. OBSERVATIONS

The MAT observed that doors and windows had variable performance. Many non-labeled doors, windows, and shutter systems were in use at facilities. The lack of labeling prevented confirmation that proper systems had been designed, tested, and installed. The sources and manufacturers of doors, windows, and shutters were unable to be identified by the MAT, the CNMI Building Safety Code Division (BSCD), the building owners, or the building operators. No windows or shutters observed had branding, testing labels, or ratings indicating wind pressure and debris impact resistance, according to ASTM International standards. Glazing systems could not be verified to be designed, constructed, or protected to current code-level requirements for wind pressures and debris-impact resistance.

The MAT observed several styles of commonly used windows that appeared to perform satisfactorily for wind pressure; however, these systems were not labeled to meet any standards. Similarly, a few commonly used shutter systems performed well and withstood impacts while protecting the glazing or doors behind them. The shutter systems used an accordion-style folding panel arrangement permanently mounted in place with tracks and hardware. These systems prevent loss of the hardware, but they lack the ability to be closed from the inside. This can be an issue when the staff has limited preparation time or the openings on the building are high off the ground, requiring personnel to use lifts or ladders to deploy the protection (Figure 14).

**Figure 14: High window with accordion shutter that was not closed during Super Typhoon Yutu, resulting in window damage (red arrow).**

In several instances, shutters were not operable because of debris, corrosion, roller damage, or track damage (Figure 15). It was observed that shutters with handle-type closing mechanisms and single-point connections were damaged prior to this event on some systems and others became inoperable after this event (likely broken or damaged by wind-borne debris). The team observed that shutters with twist lock handle systems to lock the two halves together when deployed created a single point of connection that became inoperable after being struck and broken by debris impact.

**Figure 15: Left—Impact damage of non-rated, non-labeled shutter. Right—Single twist lock handle on shutters.**

Large apparatus bay doors for fire stations generally performed poorly. The MAT observed that wind forces and wind-borne debris damaged large rolling doors that were intended to protect apparatus bays and vehicles at several fire stations. Damage occurred to the doors themselves, resulting in door failures that left the doors unusable, thus also preventing equipment from being deployed from the facilities (Figure 16). In other instances, the failure of the large doors resulted in damage to the buildings themselves and vehicles housed inside the buildings.

**Figure 16: Damage to large, rolling door at fire station apparatus bay at Fire Station 2.**

### 4.4.2. CONCLUSIONS AND RECOMMENDATIONS

#### Conclusion 11

Large apparatus bay doors at fire stations failed, exposing the building interior to wind and debris. Large rolling doors failed under wind pressure and debris impact at critical facilities. These doors suffered from track and roller failures, as well as panel failures.

##### *Recommendation 11:*

Building and facility owners should use only large rolling or sectional doors that have been tested and rated for wind loads and debris impact associated with the design criteria for the site. All door systems installed in the CNMI should be properly labeled in accordance with the building code to identify that they are pressure and debris-impact rated systems.

#### Conclusion 12

Some shutters were not operable before Yutu due to pre-storm debris-induced damage, roller damage or degradation, or corrosion issues.

##### *Recommendation 12:*

Building and facility owners should check shutters regularly and make sure that they are functioning as intended and being properly maintained, including:

- Remove debris from tracks and wash with a cleaner to remove dirt build-up.
- Lubricate the tracks annually.
- Fully deploy and operate the shutters on a regular basis.
- Repair any damaged components, including replacement of broken handles.

Refer to FEMA P-424, *Design Guide for Improving School Safety in Earthquakes, Floods, and High Winds,* for more information.

FEMA's *Public Assistance Program and Policy Guide* (PAPPG), Appendix J, recommends protecting existing windows by installing shutters or by replacing them with impact-resistant glazed systems. This includes windows on:

a. Critical facilities, such as hospitals.

b. The lower floors of non-critical facilities, which are the most likely to be struck by debris.

c. Buildings with very high-value contents that can be damaged by water (such as libraries and document centers).

d. Buildings where failure of roofing materials or other portions of nearby structures could create impact hazards.

### Conclusion 13

Some shutter systems performed well but did not have labeling or product documentation to confirm that the shutter systems met building code-required testing standards for installed products. Similarly, some windows that were protected performed adequately but also lacked labeling to indicate they were compliant with building code design and test performance levels. Without product labeling, glazing and shutter systems cannot be verified to be compliant with code requirements for wind pressures and debris impact resistance.

#### *Recommendation 13a:*

The BSCD should enforce the requirement that designers, building and facility owners, and property managers use glazing and shutter systems that are labeled with code-compliant pressure ratings and impact resistance ratings (per ASTM standards) for the protection of openings.

#### *Recommendation 13b*

Designers, building and facility owners, and property managers should consider constructing foyers and enclosed entries with two sets of doors at main entry points that are susceptible to debris impact and water intrusion from wind-driven rain. New entries added to existing buildings should be code compliant.

*Recommendation 13c:*

The BSCD should engage designers, building and facility owners, and other property managers to ensure they are aware that the building code requirements for the protection of openings for critical facilities are different than for other categories of buildings. Higher-rated products typically are required to meet the requirements at critical and essential facilities and these requirements should be identified on labels used on any products installed.

## 4.5. General Building Systems

General building systems (Heating, Ventilation, and Air Conditioning [HVAC]; Mechanical, Electrical, and Plumbing [MEP]; and Lightning Protection) consist of multiple components that are necessary to keep a building safe, serviceable, and habitable. The effect of storm-related damage to these systems can keep a facility from being habitable and can be costly to repair.

Equipment not properly secured can become dislodged and create openings in the building envelope, which can lead to water intrusion. Dislodged system components also can become wind-borne debris, damaging nearby buildings. These systems also will not perform as designed if not maintained. The most successful annual maintenance strategies are those that incorporate considerations regarding availability of replacement parts and components to reduce post-disaster recovery time and expenses. Protection of these systems is critical in the recovery process after a storm event.

### 4.5.1. OBSERVATIONS

Electrical conduit enclosures were not properly sealed. Many electrical systems and sub-systems were water soaked, including at the weather heads where systems enter the building envelope. Open panel enclosures, junction boxes, and conduit were corroded, missing gaskets, or missing covers (Figure 17). The unsealed enclosures potentially led to corrosion and damage to conductors.

**Figure 17: Left—Conduit not connected to junction; Right—Corroded junction boxes on roof of CHC.**

Similar to roof-mounted equipment, interior mechanical and electrical equipment needs to be secured to resist lateral forces. Typically, within the building, seismic forces dominate the design of these lateral systems. See FEMA P-424, *Design Guide for Improving School Safety in Earthquakes, Floods, and High Winds,* for more information.

Mini-split HVAC systems were used as a common replacement for larger or complex systems damaged during the storm. The MAT observed that installing the new mini-split systems was a cost-effective and time-sensitive approach versus repairing the original systems (Figure 18). Improperly decommissioned HVAC systems also were observed and needed to be abandoned. Facility managers often were unable to get replacement parts or find a certified technician to make the repairs to the larger systems. HVAC ducts left in place from abandoned units allowed additional damage from water infiltration.

**Figure 18: Emergency Operations Center, Left—Replacement mini-split units; Right—Abandoned condenser.**

The hospital lightning protection system was not anchored well and caused damage when it became dislodged. It was observed that inadequate anchorage, maintenance, and corrosion were the sources of failure for many of these elements. Figure 19 shows where the connectors and air terminals (circled in red) have been displaced from the roof top edge (yellow line) and not been reinstalled to protect the facility. The resulting damage can include punctures in the roof and destruction of other rooftop equipment, and it can leave the building unable to ground lightning strikes.

**Figure 19: Failed connectors from lightning protection system. Air terminals were displaced when the system connectors failed.**

National Fire Protection Association (NFPA) 780, *Standard for the Installation of Lightning Protection Systems*, 2008 Edition, advocates performing a visual inspection every year to make sure exposed components are in good working order and performing a comprehensive testing inspection every five years for any system. Additional recommendations for anchoring in high-wind conditions can be found in FEMA P-424, *Design Guide for Improving School Safety in Earthquakes, Floods, and High Winds*.

Universal components were not used throughout facilities. In many instances, there was no consistency in the materials used for MEPs. Components are purchased based on what is available or affordable, as needed, on the Islands.

### 4.5.2. CONCLUSIONS AND RECOMMENDATIONS

#### Conclusion 14

Inadequate anchoring of rooftop equipment caused damage to roof systems and building contents. For example, where HVAC components were not adequately anchored, some of the HVAC elements were blown off their mounts, damaging portions of the roof covering. The punctured and damaged roof covering led to water intrusion even when the roof covering remained in place.

> ***Recommendation 14:***
>
> Roof-mounted equipment of any type should be designed and installed to adequately resist being displaced by design-level wind speeds for the given location. Building owners, facility managers, and design professionals should make sure HVAC systems are designed and anchored to resist high wind loads; this applies to both new and existing buildings and equipment. FEMA P-424, *Design Guide for Improving School Safety in Earthquakes, Floods, and High Winds* and U.S. Virgin Islands (USVI) Recovery Advisory 2 provide specific guidance for anchoring HVAC and other equipment to the roof, roof structure, or parapets.

#### Conclusion 15

Lightning protection systems were insufficiently connected to roofs.

> ***Recommendation 15:***
>
> Building and facility owners should install lightning protection systems with mechanically fastened cables and terminals or adhesive-type systems that offer near-continuous securing of the lightning protection conductor (versus using adhered clips with "bend over" tabs). For guidance on attachment methods, see FEMA P-424, *Design Guide for Improving School Safety in Earthquakes, Floods, and High Winds*.

### Conclusion 16

Electrical and mechanical system components were not consistent throughout public buildings, schools, or other buildings. Complex HVAC systems cannot be sustained on the island due to lack of trained repair workers or lack of available parts.

#### *Recommendation 16a:*

Public building managers and building and facility owners should create a program to standardize equipment and building systems. Island systems need to be common, simple, modular, and swappable. Purchasing the materials in bulk will reduce cost and allow replacements/repairs to be made faster and more efficiently.

#### *Recommendation 16b:*

Public building managers and building and facility owners should create a Capital Improvement Plan with five-year projections to better schedule maintenance and upgrades and secure proper funding or purchase equipment on annual upgrade cycles.

## 4.6. Life Safety and Emergency Power Systems

The most important factor for managing any disaster event is preserving life. These events can develop on short notice and preparation of facilities to ensure life safety ideally should be completed swiftly. The failure of emergency and backup power inhibits the ability to maintain emergency communications, emergency alert systems, powered storm shelter systems, fire suppression systems, and water/wastewater needs.

Life safety and emergency power in the CNMI were observed to have the same overall constraints—namely, lack of certified technicians to maintain and operate equipment. Because of this lack, more emphasis needs to be placed on addressing issues between storms to minimize risk of failure to these systems. Proper efforts should be made to mitigate vulnerabilities due to wind and wind-borne debris and to address maintenance issues that may impact the ability of these systems to perform during and after an event.

### 4.6.1. OBSERVATIONS

Emergency and backup power systems failed to provide service to several public facilities as needed during and after Yutu. At the EOC, the facility's Uninterruptible Power Supply (UPS) and generator were not functional during the MAT visit, two years after the event (Figure 20). The loss of emergency power during Yutu forced personnel to relocate all functions of the EOC to a less well-equipped location due to lack of communications. Currently, the EOC communications systems are dependent on smaller, individual UPS systems located at each device to operate under all situations (i.e., during a power outage).

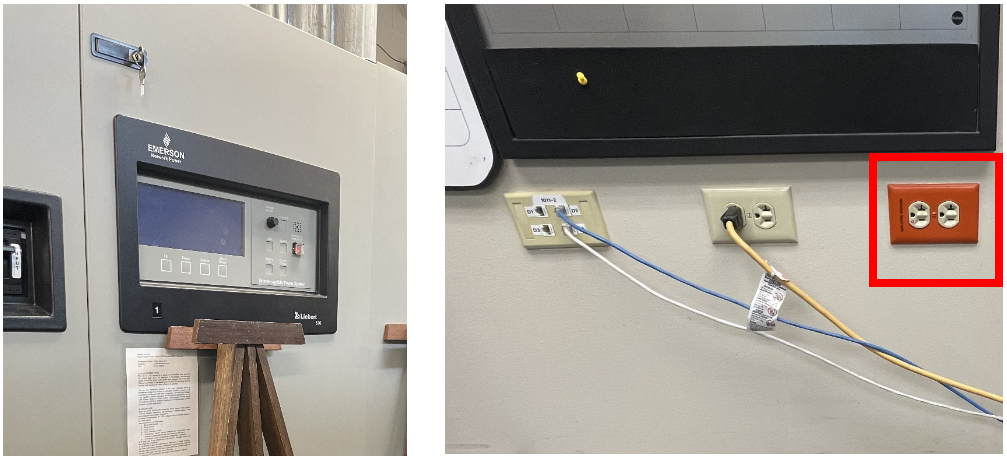

**Figure 20: Left—UPS not functioning at EOC; Right—Emergency power outlet not in use.**

In most of the school system locations visited by the MAT, there was limited emergency and backup power. Where generators were present, the generators did not have a maintenance schedule to ensure they would be ready to function during a storm event or during extended storage periods. Some of the generators did not function initially during the event because of improper storage. Demand for each unit was not calculated based on the running and start-up power needed for the use of the facility. This also caused failure due to overheating and overloading.

Portable generators were used to power on-site water pumps for some of the facilities designated for use as recovery shelters/refuge areas during storm events. Failure of several of the generators occurred due to overheating from continuous use; lack of maintenance personnel to repair or replace parts; and electrical issues from connecting the generator directly to the breaker.

There were a number of occupied facilities with only one egress. The windows and secondary paths of egress were either blocked from the inside or locked from the outside. Many schools were not prepared to be occupied as recovery shelters/refuge areas based on fire safety standards.

Some fire alarm systems in the public and school buildings were observed by the MAT to be inoperable two years after Yutu. The hard-wired audible/visual alert systems were not functioning at most facilities, requiring them to fall back on the use of battery-powered smoke detectors. However, non-interconnected devices (such as independently installed individual smoke detectors) will not alert the fire department or activate the on-site fire suppression system in the event of an emergency.

Many facilities where electrical wiring for fire alert systems was damaged during the storm event have yet to be repaired two years after Yutu. During site visits, the MAT was informed that fire alarm control panels were not functioning because of potential power surges and wind-driven rain entering through damaged or uncapped conduit. It was determined that there are minimal qualified personnel available across the CNMI to repair equipment; the inability of the public building facility departments and the school system to purchase replacement parts also exacerbated this problem.

### 4.6.2. CONCLUSIONS AND RECOMMENDATIONS

#### Conclusion 17

Generators located at schools with recovery (emergency) shelters/refuge areas were undersized, not maintained, or operated continuously at load. Most of the generators were used only to power pumps to supply water to the facility and then lights, secondarily.

***Recommendation 17:***

Building and facility owners, facility managers, and public officials should work with design professionals to size the generator for each specific site based on building code requirements (including egress lighting, emergency needs, water pump operation, etc.). Remember that designated recovery shelters/refuge areas may need a generator with additional capacity.

#### Conclusion 18

Emergency power systems lacked maintenance, and there was no visible commissioning/decommissioning procedures or install/uninstall protocol. At some facilities, the emergency/temporary generator was wired into the panel during the storm event. This can cause delays in emergency power to the facility based on availability of skilled technicians.

***Recommendation 18:***

Building and facility owners need to commission and decommission temporary emergency mechanical systems (generators, HVAC, and plumbing) after their service mission is complete, i.e., remove them after an event. Mechanical systems need to be common, simple, modular, and swappable. The addition of quick connects or redundant switch gears to critical facilities and public buildings with essential functions post-event can reduce downtime and make it easier for equipment to be maintained or replaced. Building and facility owners should develop a maintenance schedule to service mechanical equipment at the manufacturer's recommended interval during operation. Also, conduct annual inspections of electrical conduit. See FEMA P-1019 *Emergency Power Systems for Critical Facilities: A Best Practices Approach to Improving Reliability* for more information.

FEMA *Public Assistance Policy and Program Guide* (PAPPG), Appendix J recommendations:

--Install switches, circuit isolation, and/or quick connect capability to facilitate rapid connection of emergency or backup power systems for any damaged or susceptible mechanical and electrical components.

--Install camlocks, transfer switches, and electrical panels to facilitate the connection of portable emergency generators.

#### Conclusion 19

At multiple school facilities, there was one path of egress available in recovery shelters/areas of refuge during an emergency event. These areas do not conform to current life-safety code requirements.

> ***Recommendation 19:***
>
> The BSCD, in coordination with the public building managers and building and facility owners, should make sure that refuge areas have multiple access and egress points. New schools should be designed with multiple access and egress points (that include rated doors or window systems that will not be closed off/blocked by storm shutter systems).

#### Conclusion 20

Electrical wiring for fire alarm systems was damaged at many facilities during the storm and has yet to be repaired.

> ***Recommendation 20:***
>
> The BSCD, in coordination with the public building managers and building and facility owners, should make sure that repairs to life-safety equipment are completed in compliance with local codes prior to building re-occupancy. Also, use dedicated or redundant surge protection equipment on fire alarm panels.

## 4.7. Emergency Shelters versus Safe Rooms and Storm Shelters

The CNMI Office of Homeland Security & Emergency Management (HS&EM) and the CNMI Public School System (PSS) are responsible for managing the emergency shelter program and emergency shelter facilities for the territory. In the CNMI, HS&EM and PSS work together to identify school buildings to be used as emergency shelters by residents who do not want to stay in their homes during a storm; other residents come to these facilities after a storm if their homes have been damaged. These “shelters” were not designed or constructed to provide protection for occupants against high winds and wind-borne debris but, in most cases, have been retrofitted or mitigated with limited features (such as storm shutters) to harden the buildings against the effects of the storms. However, buildings identified as safe rooms and storm shelters refer to purpose-built buildings (or portions thereof) designed to provide life-safety protection during typhoons per the criteria of FEMA P-361, *Safe Rooms for Tornadoes and Hurricanes: Guidance for Community and Residential Safe Rooms*, and International Code Council (ICC) 500, *Standard for the Design and Construction of Storm Shelters*, respectively. Continuing to invest in code-compliant storm shelters and safe rooms can help protect the most vital assets of our communities: the residents.

### 4.7.1. OBSERVATIONS

During the response to Super Typhoon Yutu, the HS&EM and PSS readied 20 facilities as emergency shelters. Most of the emergency shelter facilities on the island are public school buildings, such as

DanDan Middle School, shown in Figure 21, but some private schools have been used in the past as public emergency shelters. This included:

- 15 emergency shelters on Saipan
- 3 emergency shelters on Tinian
- 2 emergency shelters on Rota


**Figure 21: Cafeteria at DanDan Middle School used as an emergency shelter.**

The buildings currently used in the CNMI as emergency shelters have not been evaluated by design professionals using a consistent methodology to determine their level of hazard vulnerability. HS&EM and PSS have selected specific buildings on school campuses to be used for these emergency shelters or refuge areas. The primary criteria in selecting the buildings for use include: (1) they are located outside of the Special Flood Hazard Area (flood zone), and (2) they are constructed of reinforced concrete frames or walls and have a concrete roof deck. In most cases, the emergency shelter buildings have windows protected with storm shutters and reinforced doors.

As noted above, FEMA and the ICC provide specific criteria for buildings to be designed and constructed to provide life-safety protection. The buildings selected for use as shelters in the CNMI provided an organized location to take refuge from the storm with some emergency services such as food, water, and cots to sleep on. They were assessed only for the ability to support the operations of event-specific and post-event services for residents. However, the buildings were not designed or constructed to provide life-safety protection from flood or wind events. Further, and in most cases, the structural systems and the building envelope systems have not been evaluated for their vulnerability to damage from extreme winds, wind-borne debris, or flood waters. Therefore, the presumption that these larger buildings, or public buildings, will perform better during typhoons and tropical storms may be incorrect. These emergency shelters, recovery shelters, and post-event shelters are simply a place of refuge only and should not be considered to provide the same level of protection as a FEMA 361 safe room or an ICC 500®-compliant storm shelter.

The MAT was unable to identify a public building or school used as a shelter before, during, or after Super Typhoon Yutu that was designed and constructed to provide near-absolute protection from a typhoon. Further, the MAT could not verify the level to which existing buildings were evaluated to serve as Best Available Refuge Areas (BARAs) during a storm. FEMA guidance recommends that buildings used as BARAs, as post-event shelters, or for any other purpose for which people will congregate in response to a typhoon should be evaluated by a registered design professional using guidance from FEMA P-361, *Safe Rooms for Tornadoes and Hurricanes, Guidance for Community and Residential Safe Rooms,* and FEMA P-431, *Tornado Protection: Selecting Refuge Areas in Buildings*, to identify the BARAs to be used.

Residential safe rooms and storm shelters can be constructed within or adjacent to homes and offer residents the ability to stay home during a storm event while safely taking refuge. FEMA provides prescriptive guidance for in-home safe rooms. The MAT was unable to identify any residential safe rooms or storm shelters constructed to the FEMA or ICC criteria.

**BEST AVAILABLE REFUGE AREA**

The term “best available refuge area” (BARA) refers to an area in a building that has been deemed by a registered design professional to be likely to protect building occupants during an extreme wind event better than other areas in the building when a safe room is not available. The BARA should be regarded as an interim measure to be used until a FEMA-compliant safe room or ICC 500-compliant storm shelter can be made available.

FEMA developed the BARA concept and checklist (see FEMA P-361) to use in assessing a building’s susceptibility to damage from extreme-wind events. The evaluation process guides registered design professionals (architects and engineers) in identifying potential refuge areas at a site with one or more buildings.

### 4.7.2. CONCLUSIONS AND RECOMMENDATIONS

#### Conclusion 21

Currently, there are no public safe rooms designed to FEMA P-361 criteria or storm shelters designed per ICC 500© in the CNMI for protection of residents during typhoons. Because evacuation from the CNMI during a typhoon event is not possible, efforts should be made to construct purpose-built safe rooms in public facilities.

#### *Recommendation 21a:*

The CNMI should consider a local amendment to the building code to require that storm shelters be designed to ICC 500© standards for select educational and first responder facilities when facilities are renovated, repaired (tied to a damage threshold), or reconstructed.

#### *Recommendation 21b:*

HS&EM and PSS should modify the design and construction of new facilities at schools to include bathroom facilities and rated doors to comply with ICC 500 storm shelter criteria (as current roof and wall construction appear to meet wind and wind-borne debris protection requirements). Recent construction projects, such as the new cafeteria building at Koblerville Elementary School (see Figure 22), could have met the FEMA safe room or ICC 500 storm shelter criteria if doors and windows compliant with ICC 500 requirements had been installed, if bathroom facilities had been provided within the building (per criteria), and if emergency power systems had been provided.

**Figure 22: New cafeteria at Koblerville Elementary School identified for use as an emergency shelter, but was not designed to meet FEMA or ICC life safety protection criteria.**

### Conclusion 22

The existing shelter program in the CNMI is not tied to specific design and construction criteria that will provide life-safety protection for shelter occupants.

#### *Recommendation 22:*

HS&EM should establish a program for safe rooms and storm shelters across the CNMI that provides consistent criteria and standards for the facilities being designed for life-safety protection using FEMA 361 criteria and the ICC 500 requirements. Identify a lead agency to manage the shelter program across public facilities.

### Conclusion 23

Many buildings currently being used as shelters and refuge areas were not evaluated by design professionals for flood, wind, and seismic vulnerabilities.

#### *Recommendation 23:*

The CNMI should consider developing a BARA assessment program. HS&EM, DPW, PSS, and other stakeholders should consider collaborating to develop a program to evaluate existing buildings for BARA use before, during, and after storm events. Until such buildings can be constructed, facilities being used as emergency shelters should be evaluated using the FEMA BARA methodology to provide consistent evaluation and understanding of the facilities being designated for use during storms.

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Super Typhoon Yutu CNMI MAT – Related Fact Sheets and Recovery Advisories:

- Fact Sheet 1: Maintenance for Roof Coverings, Windows/Doors, Shutters, and Exterior Building Elements
- Fact Sheet 2: Maintenance for Critical Building Systems
- Recovery Advisory 2: Mitigating Wind Damage to Existing Critical Facilities