International Journal of Education and Human Developments, Vol. 9 No. 1; March 2023
ISSN 2415-1270 (Online), ISSN 2415-1424 (Print)
Published by Center for Global Research Development

Mitigating Natural Disasters: Innovating Jail Architecture Through Structure

Shideh Shadravan[1]
Marjorie Callahan[2]
Johanna Hilmes[3]

The University of Oklahoma
United States

Abstract

Carceral architecture is designed for confinement, security, and isolation. Architecture has been used as a tool in the suppressive agenda of the penal system. In recent years, however, researchers and politicians have been reexamining the incarceration system and are pushing for a shift from the current punitive state toward rehabilitative styles. Despite designers reimaging the architecture and interiors of these facilities, they have failed to consider the structure. Architects and engineers' structural innovation must prioritize focus on producing designs that mitigate the effects of a natural disaster for all human beings.

This paper studies innovating carceral structures for emergency preparedness in response to increasing severe weather, and the challenges of protecting the populations within these facilities. The study is performed by analyzing the history and purpose of prison systems and how modern physical forms were developed as an effect. Case studies of both newly constructed and retrofitted weatherproofed hospitals are explored as precedent projects for applying techniques to a similar format of facility. It is found that to prepare a prison to withstand emergency situations, the structure of the building should be designed to protect the population where they are and minimize the need for relocation.

Key Words: Carceral Studies, Emergency Preparedness, Mitigation, Case Study Method, Structural History, Risk Management

PAPER

1 INTRODUCTION

1.1 Importance of this Work from Research into Literature Reviews

The global increase in frequency and intensity of severe weather and natural disasters has directed focus to the resiliency of built environments. Design professionals are essential components in the discussion of emergency preparedness. Architects and engineers exercise structural innovation to produce designs that mitigate the effects of a natural disaster. Mitigation design "is the action taken to eliminate or reduce the loss of life and property damage related to an event or crisis, particularly those that cannot be prevented [1]. Therefore, mitigation is essential to best protect the vulnerable community in a large-scale facility.

Revolutionizing the structural design and intent of carceral facilities the authors look toward history. This raises the questions: What was the origin of these facilities, what were they intended to accomplish, and have these orientations changed since their conception? More importantly what should the future of these facilities accomplish? The tide is turning from punishment to rehabilitation, restriction to reintegration, humiliation to humanity. Accomplishing this shift must include structural design consideration and innovation.

Prison architecture has not been studied to show how humans can safely escape disasters and emergencies. The penal building type presents unique challenges to formatting emergency protocol because of the strict security measures, large population, and inability to react and protect oneself. However, many studies have dealt with designing architecture to protect against natural disasters in comparable building types, like hospitals. Therefore, these case studies assess similar concerns and suggest applicable design elements relevant to designing against disasters in the penal and social justice building types.

1.2. Hypothesis

This literature review research provides a recommendation in the form of a hypothesis: "if jails/prisons are designed to a higher level of robustness with multiple on-site design features in place, then facilities will be self-sufficient in the even to disaster" [2]. Furthering this declaration, a related set of research observations need to be considered: (1) staff have high turnover rates therefore protocols need to be intuitive and simple; (2) structures should be inclusive of, and beyond, fire emergency, generators, water supply, ventilation, and light; (3) increase awareness of detention of prisoners (cells, handcuffs, locked access) [3]; and (4) reliability of trusting emergency planning and training by local officials [4].

The topic of combatting natural disaster impacts on our built environments is imperative work for architects and engineers. The vulnerability of incarcerated persons and employees to natural and other hazardous disasters first depends on the physical environment and structure of a facility. Ensuring that a building is structurally secure in the case of an emergency is the safest and most effective way to protect these populations. In order to build with improvement for the future, designers must learn from the past.

2 HISTORY of PRISON BUILDING

2.1 Ancient and Historic Prison Architecture

Ancient prisons (1st to 3rd millennia BC) were primarily used to hold prisoners to be used as slaves or until their impending death sentence [5]. While the purposes were universal, the structure of the prisons varied by civilization. The Mesopotamian, Egyptian, and Roman prisons were situated in "underground dungeons" where prisoners were either "chained to the walls" or kept in small, claustrophobic cells [5]. Greek prisons favored a detention method of wooden blocks attached to the feet of prisoners instead of underground dungeons [5]. In contrast to western ancient worlds, China used prisons as forms of punishment physical retribution instead of holding a criminal until execution [6]. The offenders of these ancient prisons were typically "common criminals, slaves, prisoners of war, debtors and those convicted of treason" [7].

A new era of prisons architecture evolved around the end of the 12th century (1298) with influence from the Catholic church and its disapproval of the death penalty or physical punishment [8]. The transition to imprisonment as a form of punishment rather than execution is where prison architecture became a more concrete concept [8]. Prison design resembled that of churches, notably the "cellular design" taken from churches and monasteries [8]. Prison architecture also borrowed the design of the "'house of penitents'" within monasteries for what would be cells [8]. Other key features of this era of prison architecture include "thick walls, round arches, sturdy piers, groin vaults, large towers, decorative arcading and symmetrical plans," which ultimately resulted in fortress-like exteriors [8]. The common building materials were wood inside stone walls (often exceeding 10 feet thick) [7].

The modern era of prison architecture began in the late 1700s because of the "first 'prison boom'" [9]. Following the Revolutionary War, England could no longer exile prisoners to America. This increased the volume of prisoners within England and created a need for structures that could manage the heightened incarcerated population [9]. America was concurrently facing problems of its own with a growing population and lack of law system [9]. New prison proposals were developed as a response to societal changes, most notably, the panopticon design [8]. This new design, imagined by Jeremy Bentham in 1785, was based on "allow[ing] an observer to observe (-opticon) all (pan-) prisoners without the incarcerated being able to tell whether or not they are being watched" [8]. The circular structure with a guard tower at the center of the accomplished this goal [9]. The unknowingness added a new element of discipline to prisons, provided by the structure [8].

2.2 Modern Penal Structures

The panopticon design structure spurred exploration of different prison layouts through the 18th-21st century. The most immediate rendition following the panopticon was the radial design [10]. The radial design followed the panopticon's central surveillance and 360º of surrounding cells [10]. The main modification was that instead of the cells being house in one solid structure, they broke off in to wings the jutted out from the core [figure 1 and 2] [10].

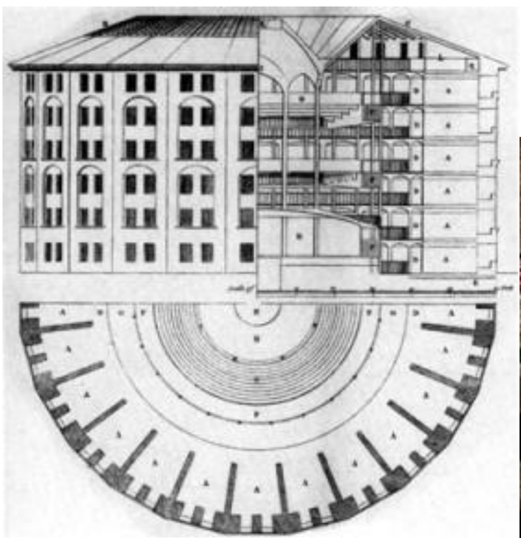

Figure 2: Bentham's Panopticon [10]

Figure 1: Radial; Gartnavel Royal Hospital [10]

The telegraph (or telephone) pole layout came out in the 1800s and is one of the most common designs of existing prisons [11]. The structure is characterized by a main corridor with parallel hallways of cells [11]. Initially intended to "increase[ed] security and restrict[ed] movement of inmates outside of the corridors," the long hallways ultimately made the facility more difficult to monitor [11]. The campus style designs (separation of buildings) emerged in the mid-1800s as a contrast to the telephone pole layout [11]. The pod structure minimized the number of prisoners and the surface area within a building to assist with observation of the area.

These are not the only existing prison layouts of the modern era. There are other variations and combinations of designs that have been experimented with to try to accomplish the best structure to surveil inmates and maintain the peace. However, that is the limit of what prison architects and engineers consider when it comes to the structure of the facilities. These designs are all related to how to best manage and surveil inmates. Glaringly obvious is the exemption of discussion on structural safety and resiliency (figure 3).

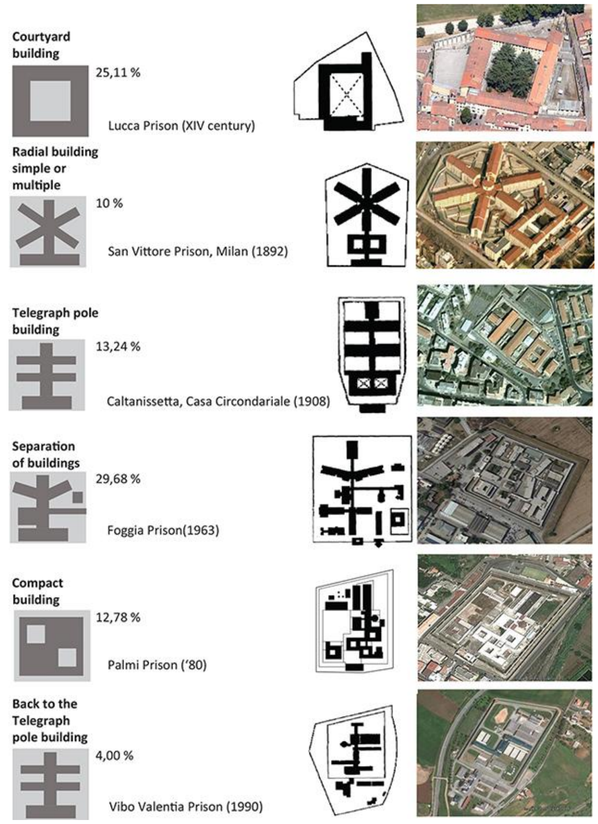

Figure 3: Prison Layouts [12] I couldn't find the refence. So I may remove it.

3 NATURAL DISASTERS ON PRISONS

3.1 The Effects of Natural Disasters

The apathetic approach to prison architecture, especially in the wake of a natural disaster, has shown time after time to have devastating impacts on the people within the facilities. Hurricane Katrina, one of the most infamous natural disasters in modern history, took hundreds victim, left thousands homeless, and disrupted people's lives and sense of security for years to come. When looking at how people were affected and the wreckage that Katrina left, the experiences of the those who were incarcerated are overlooked. In the words of Eric Balaban, a staff attorney for the National Prison Project "Because society views prisoners as second-class citizens, their stories have largely gone unnoticed and therefore untold" [13].

They could not evacuate at the warning of the storm, they could not be with their families during the time of despair, they could not act on their survival instincts to protect themselves and their loved ones. Instead, the lives of the roughly 6,500 prisoners of Orleans Parish Prison (OPP) were put in the hands of the correctional officers [13]. While the rest of the city of New Orleans followed the mayor's declaration of the "city's first-ever mandatory evacuation," the sheriff stated that "prisoners would remain 'where they belong'" [13].

The implications of this decision resulted in sheer horror. The prisoners of OPP were left in "chest level" flood waters and "kept for days without food, potable water or ventilation" [14]. Eventually they were evacuated in the midst of the storm, which led to the prisoners being "held at gunpoint on a highway overpass surrounded by floodwaters" [14]. The effects of unpreparedness domino into lists of additional issues including infections, prisoner escapes, inmate transfers, and ultimately, chaos.

These experiences have led to the understanding that guards are not equipped well enough to make this scale of a decision or to manage this large of an emergency plan; that evacuation is not a viable option; and that the building needs to be designed to protect the inhabitants where they stand.

4 CASE STUDIES

While disasters occur in all states and all countries – tornados, hurricanes, snowstorms, earthquakes, tsunamis, floods – the case studies for this report have been narrowed to distinct states in the United States that face harrowing disasters on the strongest scales that affect the structural and systematic integrity of carceral facilities. The case studies looked at in this report consist of precedent jails and hospitals. Due to the lack of disaster-resistant prison structures, hospitals studies have helped to fill the gap because of their operational similarities; hospitals and prisons both have physically limited populations, inhibiting evacuation.

4.1 New Construction

Mercy Hospital – Joplin, Missouri

After an EF-5 tornado devastated the city of Joplin, Missouri and the local hospital, St. John's Regional Medical Center, in May 2011(figure 4). All windows were blown out of the hospital, the power generator was blown out of the building, and "one of the hospital's towers took a direct hit by the storm and was rotated four inches on its foundation" (figure 3) [15] [16]. The structure was steel frame and concrete frame, and its damage condition was "damage/loss of roof and/or wall cladding" [17]. It was rendered a complete loss of functionality [17]. When analyzing where the architectural preparation failed, Mercy hospital's vice president of facilities stated, "We plan for if we lose power, if we lose water, we plan for a lot of emergencies, but we never plan to just lose everything" [18]. A team of contractors, engineers, and architectural firms were commissioned to design Joplin's new hospital.

Figure 4: Damage to St. John's Regional Medical Center in Joplin, Missouri following the 2011 tornado [19]

The architects and engineers of Mercy responded to the devastation with innovations to provide defense against the strong winds, water damage, flooding, and electricity reliability. The original St. John's hospital was leveled, and Mercy was constructed from scratch at a new location. The new structure was 7 floors, 900,000 square feet, over 260 private rooms, and included "unprecedented 'storm hardened' safety features" [20] [21].

The architects of the hospital, HKS, noted that there were two primary lessons learned in the design process. The first is to "provide safe passage through exit corridors" [21]. To do this, the studs in the corridor walls were carried through the ceiling structure, and "storm resistant doors and hardware" were installed [21]. The second lesson was the importance of providing "safe passage through stairs" [21]. This was accomplished with additional backup lighting, and walls that were constructed to hurricane standards [21]. TIME Magazine called Mercy Hospital a "paragon of virtually tornado-proof construction" [22].

Additional innovations and improvements include:

- Specially commissioned windows that can manage up to 250 mph winds [22]
- "Windowless safe zones" [22]
- Buried electrical wiring [22]
- "stand alone 'hardened' building" for the central utility plant [23]
- "waterproof 'membrane' and concrete slab […] beneath the roof, designed to stay put even if the outermost layer peels off" [22]

These innovations have an obvious application and importance when considering carceral structure design as well. They are generalized weather-proofing techniques to create an all encompassed safe structure. The two primary lessons the HKS architects identified – keeping exit passages and stairways safe – are also relevant when thinking about carceral design. While this report has stated that constructing a structure to protect prison population where they stand is the most effective way to keep people safe, there must be effective routes to move large populations of people in and out of the building if necessary evacuation or significant damage to the facility occurs.

When looking to instate stronger and more successful architectural techniques, cost is a looming question. While certain aspects of making a more resilient structure are costly, Masonry Contractors Association of America (MCAA) stands to state that Mercy Hospital's improved "hardened exterior" design will only add roughly "2 percent to 3 percent to the construction costs" [19]. The total cost of the structure was $345 million [21].

Nantucket Cottage Hospital – Nantucket, Massachusetts

The Nantucket Cottage Hospital in Massachusetts (figure 5), designed by architecture firm Cannon Design, was built to attain a level of emergency preparedness that can withstand Category 5 winds among other threats to the structure [25]. The $89 million facility was imagined as a refuge that will be able to remain open for victims to receive medical treatment even when all other facilities are closed from hurricane devastation [25]. To accomplish this level of structural stability the building is constructed with "5-foot-by-5-foot concrete footings fortified by mesh, Andersen Stormwatch windows and a double-hulled exterior building shell" [25]. As in the event of a tornado, strong winds are only one of many threats to the building in the occurrence dangerous weather.

Figure 5: Newly Constructed Nantucket Cottage Hospital [24]

Many buildings utilize basements as a common technique to provide a space of refuge from strong winds, but Nantucket Cottage Hospital completely foregoes this design idea after learning from Bellevue Hospital's experience during Superstorm Sandy in which their basement flooded resulting in a power outage [25]. Nantucket Cottage instead designed the workings of their "boiler room" to be located on the roof [25]. This design acts as a fail-safe to prevent one area of weakness from creating a domino effect and triggering other avoidable damage. This is not the only fail safe included in the design. There are many communication "redundancies" put in place including "analog and digital phone lines and access to satellite phones" [25]. Additional architectural innovations of emergency preparedness include:

- Transformer switches on the second floor
- Waterproof curbing for fuel-pumping room
- "water and vapor barrier" between double-hulled shell
- "enough food for seven to 10 days"
- "27,000 gallons of fuel on-site for the [two] dual purpose generators" [25]

The structure and architecture underlying the 106,000 square-foot, 14 bed building is innovative and progressive [25]. The hospital is small in stature, fitting for the community that it serves. Again, the innovative designs and perspectives produced by the architectural and engineering professionals in this case study provide precedence for prison design. The Nantucket Cottage Hospital shows tactics to eliminate the threat of potential flooding in basements and the difficulties associated with it, while also providing alternatives to a basement as a storm shelter.

4.2 Retrofit

<u>Nicklaus Children's Hospital – Miami, Florida</u>

The Nicklaus Children's hospital in Miami (figure 6), Florida was tested for "resilience to potential storm damage" to ensure that it will stand up to aggressive storms in Florida [26]. The results showed that the existing exterior would not hold up in the case of Category 2 or higher wind speeds, therefore the three-story, 268 bed hospital underwent a retrofit in 2001 [26].

The price tag of the project was $11.3 million, a fraction of the costs associated with new construction of this type [26]. The retrofit came in the form of installing "pre-molded panels of glass fiber-reinforced concrete" to encapsulate the structure, as well as replacing the existing windows and roof with strengthened versions [26].

Figure 6: Nicklaus Children's Hospital following 2001 retrofit [29]

Clark Pacific, a leading distributor of glass fiber-reinforced concrete (GFRC) panels, has served number of healthcare facilities with their product and services. Clark Pacific shows that their paneling does more than just secure a building against wind speeds. The facade systems "meet or exceed Title 24, water & vapor barrier requirements," are ideal to increase structural stability against seismic activity and are fire resistant [27] [29].

One of the main concerns of retrofitting an essential building is keeping the facility operable while undergoing construction. The Nicklaus Children's Hospital was able to do so by a strategy that saw construction being completed from the outside in [26].

The same concern is relevant in a potential carceral retrofit. If a jail or prison needs to undergo building improvements, there is not an appropriate option to disperse all existing incarcerated people of that facility during the construction period. This construction strategy also eliminates this barrier as a reason that a facility may opt to not undergo structural building improvements.

5 CARCERAL STRUCTURE ANALYSIS AND RECOMMENDATION

This study offers two categories to be considered by architectures and structural engineers in jail and prison design: first, how to retrofit existing prisons/jails to have improve resilience and emergency preparedness, and secondly how to design new jails/prisons to have a safer structure and better resilience to severe natural disaster.

1) It is more challenging to improve the structural resilience of existing jails or prisons against natural disasters than to construct a new facility. However, the level of difficulty directly depends on existing factors of the building and its site, such as location, year of construction, structural design, space for expansion, and condition of the building. For example, if a jail/prison is in an area that is at risk of tornados, using the existing basement could be an option as a shelter. However, the basement must be large enough, or have space to expand, to include essential facilities (community rooms, bathroom, good plumbing) for it to function as a shelter that can accommodate potentially hundreds of people.

If the jail/prison is at risk for hurricanes, basements are not a viable option because flooding is a serious concern. Therefore, the shelter must be considered above the ground. One option is to build a structurally safe addition that could act as a storm shelter, however, there must be enough space on the property to expand. As was the case with the proposed basement shelter for tornados, there must be enough space in the addition to accommodate hundreds of people, as well as food and water, for a minimum of one week. However, if there is no space to build an additional building on the property, the structure of the existing building must be retrofitted to withstand natural disasters. For instance, creating/building shelter inside or attached to the existing building, replacing the existing windows with windows that can resist high wind speed, or using glass fiber-reinforced concrete.

If the jail/prison is in seismic area, it will be difficult to relocate prisoners even to the additional building as shelter because seismic is not predictable like tornados and hurricanes. In this case, this type of building must structurally be safe on its own like hospitals. Therefore, structural engineers must be involved and evaluate the existing building and the options of how to best reinforce the existing building.

2) For a new prison construction, the goal is to construct a resilient building and a safe place without evacuation in a severe weather. Therefore, each detail in entire building is required to be reviewed and the standard tornado/hurricane/… safety and building codes must be modified by architects and engineers. According to the case study in this paper, St. John's Mercy and Nantucket Cottage Hospital are the two new hospitals recently built considering design improvement to withstand in hurricanes and tornadoes. As it has been mentioned, some of the feature used in these designs are increasing roof resiliency by using a concrete slab under the roof, using resilient windows for high-speed wind, creating windowless safe zones in the building, using waterproof membrane, and making a safe floor as a shelter above ground.

The authors also recommend providing tornado resistant door and frame systems that are watertight flood-proof doors with sealed frames. These doors will have double functions: securing the prisons and withstanding sever weather. Furthermore, as roofing resiliency is very important to remain functional in severe weather, the roof connection to the structural system of building plays an important role in preventing roof uplift and withstanding severe winds. Therefore, the proper and secure connections especially in perimeter, edges, and corners of the roof to the structure is emphasized in design.

Clearly, lateral load resisting systems must be considered in design. This includes shear wall, moment frame, and braced frame using materials such as reinforced concrete, pre-tensioned concrete, masonry, steel, or a combination.

CONCLUSION

In the authors' own community, tornadoes are a common part of life. In the aftermath of these disasters and destruction of Oklahoma lives and built environments, Architects-Engineers-Weathermen-School /Hospital/Nursing Home Administrators (to name a few) work diligently to address this continually challenging phenomenon. However, even in moments when community comes together at its strongest, there are still those who are forgotten. In a county courthouse this past year, a presiding Judge inquired why the Oklahoma County Jail was not included in the mission to '*prioritize focus on producing designs that mitigate the effects of a natural disaster* ***for all human beings***.'

Today's carceral architecture is moving past designs of confinement, security, and isolation towards a more rehabilitative and humane mindset. A tough global issue, perhaps better put as a call for citizens, architects, and engineers to consider *all* human beings first and foremost. The authors of this paper are suggesting one of the first calls to action: architects and engineers must prioritize producing designs that mitigate the effects of natural disaster to protect everyone – inclusive of immobile or in a locked cell – equally.

SOURCES

[1] Emergency Management
Author: Cornell University
https://emergency.cornell.edu/cuemp/#prevention

[2] Introduction to Emergency Management
Authors: Brenda Phillips, David M. Neal, Gary Webb
https://www.taylorfrancis.com/books/mono/10.1201/9781315394701/introduction-emergency-management-brenda-phillips-david-neal-gary-webb
- Citation provided by Marjorie. See for access
- Potentially page 13

[3] Pararua Men's Prison: A Social and Political History (2012)
Author: Toni Symon
https://ir.canterbury.ac.nz/handle/10092/7775

[4] Abandoned and Abused: Prisoners in the Wake of Hurricane Katrina
https://journals.sagepub.com/doi/abs/10.1177/0306396807080069
Author: N/A
- Citation provided by Marjorie. See for access

[5] History of Prisons
Author: N/A
http://www.prisonhistory.net/prison-history/history-of-prisons/

[6] Prisons and Imprisonment in the Ancient World: Punishments Used to Maintain Public Order **Author:** Wu Mingren ('Dhwty')
https://www.ancient-origins.net/history-ancient-traditions/prisons-and-imprisonment-ancient-world-punishments-used-maintain-public-020588

[7] Understanding Our Roots: A Brief History of Prisons
Author: Lynne Woodruff
https://www.lexipol.com/resources/blog/understanding-roots-brief-history-prisons/

[8] Disciplinary Architecture: Prison Design and Prisoners' Health
Author: Niyi Awofeso
https://hekint.org/2017/01/29/disciplinary-architecture-prison-design-and-prisoners-health/

[9] The evolution of prison design and the rise of the direct supervision design
https://www.lexipol.com/resources/blog/the-evolution-of-prison-design-and-the-rise-of-the-direct-supervision-model/
Author: Lynn Woodruff

[10] Radial Plan Institutions
https://www.asylumprojects.org/index.php/Radial_Plan_Institutions
Author: N/A

[11] Prison Architecture and Inmate Misconduct: A Multilevel Assessment
Authors: Robert G. Morris and John L. Worrall
https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.873.7189&rep=rep1&type=pdf

[12] Figure 3
- Image provided by Marjorie. See for source (I couldn't find the resource. So I remove it.

[13] National Prison Project Calls for Immediate Action by President, Congress and Justice Department
Author: N/A
https://www.aclu.org/press-releases/aclu-report-details-horrors-suffered-orleans-parish-prisoners-wake-hurricane-katrina

[14] In the Eye of the Storm: When Hurricanes Impact Prisons and Jails
Author: Matthew Clarke
https://www.prisonlegalnews.org/news/2018/may/17/eye-storm-when-hurricanes-impact-prisons-and-jails/

[15] Five patients who died in Joplin hospital suffocated
Author: Kevin Murphy
https://www.reuters.com/article/us-usa-weather-tornadoes-hospital-idUSTRE74N7FB20110524

[16] Joplin Hospital – Case Study
Author: N/A
https://www.anovafurnishings.com/journal/case-studies/joplin-hospital#:~:text=On%20May%2022%2C%202011%2C%20St,winds%20estimated%20at%20200%20mph.&text=One%20of%20the%20hospital's%20towers,was%20structurally%20unsafe%20and%20St.

[17] Technical Investigation of the May 22, 2011, Tornado in Joplin, MO
Author: Long Phan
https://www.nist.gov/system/files/documents/2017/05/09/NCSTAC-Joplin4-Phan-FINAL.pdf

[18] 7 years after Joplin tornado, Mercy builds hospitals with disaster in mind
Author: Sarah Fentem
https://news.stlpublicradio.org/health-science-environment/2018-06-18/7-years-after-joplin-tornado-mercy-builds-hospitals-with-disaster-in-mind

[19] TORNADO-RESISTANT HOSPITAL TAKES SHAPE IN JOPLIN, MO.
Author: N/A
https://www.masoncontractors.org/2013/05/24/tornado-resistant-hospital-takes-shape-in-joplin-mo/#newsletter

[20] Mercy Joplin Quick Facts
Author: N/A
https://www.mercy.net/newsroom/mercy-hospital-joplin-quick-facts/

[21] Joplin Storm Imparts Valuable Design Lessons
Author: Norman Morgan
https://www.hksinc.com/our-news/articles/joplin-storm-imparts-valuable-design-lessons/

[22] The (Virtually) Tornado-Proof Hospital: What Moore Can Learn From Joplin
Author: Andrew Katz
https://science.time.com/2013/06/01/windows/

[23] Wind-Resistant Construction Key to Rebuilding for Resilience
Author: N/A
https://toolkit.climate.gov/case-studies/wind-resistant-construction-key-rebuilding-resilience

[24] New Hospital Delivers
Author: Bruce A. Percelay
Photography by: Brian Sager
https://n-magazine.com/new-hospital-delivers/

[25] New hospital being built to survive strongest hurricanes
Author: Cynthia McCormick
https://apnews.com/article/c6ea5a8afef2454784b420022a900975

[26] Retrofitting a Children's Hospital with a Hurricane-Resistant Shell
Author: N/A
https://toolkit.climate.gov/case-studies/retrofitting-childrens-hospital-hurricane-resistant-shell

[27] Clark Pacific – Products
Author: N/A
https://www.clarkpacific.com/products/

[28] Clark Pacific – Glass Fiber Reinforced Concrete (GFRC)
Author: N/A
https://www.clarkpacific.com/gfrc/

[29] Miami Children's Hospital Expansion and Renovation
Author: N/A
https://www.de-simone.com/projects/project/miami-childrens-hospital-expansion-and-renovation/