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Analyses of Temporary, Semi-permanent, and Permanent Construction Standards on Expeditionary US Air Bases

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Analyses of Temporary, Semi-permanent, and Permanent Construction Standards on Expeditionary US Air Bases

by

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Dedication

To my parents, my first teachers, for providing me the foundation from which every blessing and success is made possible. To my beautiful wife, who without fail was down in the trenches with me during the many late nights, eager to support in any way possible, be it through quality control, transcription of number after number after number, or providing much needed study break distractions via Aurora, Houston, HQ, and *The Office*.

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Abstract

Analyses of Temporary, Semi-permanent, and Permanent Construction Standards on Expeditionary US Air Bases

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Temporary, semi-permanent, and permanent military assets are constructed for intended lifetimes to support personnel operating at bases around the world. The prolonged use and repurposing of assets leads to physical, social, and economic issues. These issues may be mitigated through risk-based asset management investments, including initially constructing assets with consideration of realistic intended operation durations or replacing and transitioning assets to support an enduring presence throughout each asset's lifecycle. As bases become more developed, as population increases, or as missions change, upgraded construction standards may warranted. There is limited research regarding the factors that impact the decisions for the various constructions standards. This study seeks to understand how the US Air Force applies construction standards to assets at two overseas bases classified as transitioning from expeditionary to enduring; and the extent application aligns with policy. The sources of sample data were real property spreadsheets and sustainment management system facility reports. This research uses Chi-Square and ANOVA hypothesis testing to explore the relationships between construction standards by **category**, **location**, and individual **base**. Identifying differences between bases and between asset management planning and execution could help drive behavior changes and inform investment decisions. The test results indicate that Base A, where there is more overlapping of construction standard characteristics and more distinct asset prioritization, may be further in its transition to enduring than Base B, where construction standard characteristics overlap less and different facility categories on average share similar importance levels. Inconsistencies between variable relationships (e.g., building category and condition index are related for Base A but not for Base B) between the bases highlight differences in how each base prioritizes and maintains facilities and how long facilities are used. Evidence shows semi-permanent and temporary facilities are operated past their intended lives at both bases; in some instances for over twice as long as intended. However, less than 25% of facilities exceed their intended age by more than five years and of those, a majority have high building condition indexes. The test results for both bases mostly support the policy to primarily construct permanent structures and use temporary facilities as interim solutions.

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1. INTRODUCTION

In recent decades, several research studies have focused on the design, planning, and use of infrastructure and facility assets. While these assets are constructed for intended lifetimes, assets classified as temporary or semi-permanent have often been used past their originally intended durations; at times for purposes, which they were not originally designed. Prolonged use and repurposing of assets can potentially lead to physical, social, and economic issues. Users of temporary shelters can experience mental stress, ethnic tension, and close quarters (Arlikatti, Andrew, Kendra, & Prater, 2015). Additionally, owners may spend more resources maintaining temporary or semi-permanent assets than what the cost to replace them would be (Arslan, 2007). These issues can be potentially mitigated by making risk based asset management investments to either construct assets appropriately, according to realistic intended operation durations so future transition is not required or to replace and transition the assets in a portfolio to more permanent construction standards at appropriate times throughout each asset's lifecycle.

Assets are temporarily, semi-permanently, or permanently employed in various civilian and military capacities. In the civilian sector, transient workforces, including fly-in fly-out oilfield workers, miners, and construction workers, require temporary infrastructure and facility assets to satisfy basic daily needs and services (e.g., McKenzie, 2011; Boyd, 2017). Similarly, infrastructure and facility assets are constructed in the military sector to support the personnel that live and work on strategically located bases around the world. Although often thought of as distinct sectors, an instance when both the civilian and military sectors employ temporary, semi-permanent, and permanent assets is post natural and man-made disaster recovery efforts (e.g., Shaw & Goda, 2004; McCarthy, 2012; Félix, Monteiro, Branco, Bologna, & Feio, 2015). Post disaster, both the civilian and military sectors face challenges on how to efficiently and quickly construct and distribute shelters, provide electricity and clean water, and support displaced persons including disaster victims and refugees over an extended period (McDonald & Ovca, 2017).

Despite the significant contributions from previous studies on transient workforces, military assets, and disasters, there is limited research regarding the conditions or factors that impact the decisions for the various construction standards. *This study seeks to understand how the US Air Force applies temporary, semi-permanent, and permanent construction standards to facility assets at two overseas military bases classified as transitioning from expeditionary to enduring (defined further on)*. To better understand the current state of practice, a civilian and military sector literature review was conducted that focused on: (1) uses of temporary and permanent facilities and infrastructure; (2) construction standard decision making considerations; (3) post disaster reconstruction phases where the use of temporary constructed facilities and infrastructure is prevalent; and (4) findings pertaining to the transition of assets from temporary to permanent construction standards.

In both the civilian and military sectors, temporary facilities include (but are not limited to) shelter, housing, and office space, while temporary infrastructure includes (but are not limited to) water supply, sanitation, and energy. In the civilian sector, while individual temporary assets have associated service lives, the temporary construction standard does not necessarily have a predefined usable life. Temporary asset investments can either be at minimal cost with an intended duration between a few weeks to several months or at an increased cost with an intended duration as long as a few years. Regardless of the duration of use, a temporary standard for the civilian sector is designated for assets that will be constructed, operated, and eventually decommissioned (Johnson, Lizarralde, & Davidson, 2006), or in certain instances, transitioned, into more permanent and durable, but often more initially expensive construction standards (Joint Engineer Operations, 2016).

In military applications, while the intended durations of use for the distinct construction standards are well-defined, base classifications are referred to using multiple terms from different publications and construction standard references. The Red Book (Engineer Pamphlet 1105-03-1, 2009), The Sand Book (USCENTCOM Reg 415-1, 2004), and Joint Publication (JP) 3-34, (Joint Engineer Operations, 2016) are military publications that provide construction guidance for specific geographical locations. The various classifications from these publications include austere, bare, expeditionary, organic, initial, temporary, semi-permanent, permanent, established, and enduring (Miller, 2011). The United States European Command (USEUCOM) uses The Red Book and the United States Central Command (USCENTCOM) uses The Sand Book as a baseline for contingency construction (Miller, 2011). The JP 3-34 is used in all commands including USCENTCOM. The bases used in this case study fall under USCENTCOM therefore, definitions from The Sand Book and JP 3-34 are used in this study.

The Sand Book and JP 3-34 classify bases as either "contingency" or "enduring." A base is classified as "contingency" when the base is on a short-range planning horizon, typically less than two years, and "enduring" when the bases is on a long-range planning horizon, typically greater than or equal to two years. Additionally, military engineers are educated on multiple other standards relevant to specific base classifications of expeditionary or enduring. These standards include (but are not limited to) Unified Facility Criteria, Life Safety Codes, and Occupational Health and Safety Standards. These standards at times differ from contingency standards outlined in The Sand Book and JP 3-34 (Miller, 2011). Commanders, therefore, with approval from the Secretary of Defense

(SecDef), must decide on a classification and appropriate standard for the base (Joint Engineer Operations, 2016).

According to JP 3-34, the continuum of construction standards from temporary to permanent can be more specifically defined as organic, initial, temporary, semi-permanent, and permanent. Each standard is based on the intended duration of use and operation support required. Organic construction is provided for initial force activities before engineering resources arrive. Organic construction requires no external engineer support besides the unit organic equipment and systems, and is intended for 90 days to six months of use. Initial construction requires minimal external engineering design support and is intended for up to six months of use. Temporary construction is intended for less than five years of use. Temporary construction is characterized as providing an improved quality of life for occupants from the initial construction standards and uses locally available materials and expedient low-cost construction techniques. The temporary construction standard is often employed when a base's classification transitions from contingency to enduring. Semi-permanent construction is intended for less than 10 years of use but can be used for up to 25 years if properly maintained. The semi-permanent standard is characterized by more enduring facilities. Finally, permanent construction is intended for greater than 10 years of use (Joint Engineer Operations, 2016). Construction on enduring bases follow semi-permanent and permanent standards.

1.1. CIVILIAN SECTOR

In the civilian sector, there are many applications of temporary facilities and infrastructure. One area where these assets are commonly used is the expediently constructed temporary accommodations for the oil industry's peripatetic workforce (McKenzie, 2011). Another area is in the disaster management cycle post either natural disasters, such as severe weather, earthquakes, and wildfires, or manmade disasters, such as oil spills, armed conflicts, terrorist acts, or chemical, biological, radiological, and nuclear (CBRN) incidents (Joint Engineer Operations, 2016; Pinera & Reed, 2007). Displaced persons due to natural disasters or manmade disaster can be civilian or military personnel from the impacted area or refugees from foreign countries. Although there are other instances where temporary facilities and infrastructure are employed, such as to accommodate the needs of tourists attending a special event like a state fair, this study will only focus on peripatetic workforces and displaced disaster victims uses because they most closely relate to the temporary military applications of facility and infrastructure assets.

1.1.1 Temporary Assets in Boomtowns

Boomtowns are communities that experience rapid economic growth due to a "boom" in a natural resource like oil. North Dakota, for example, has boomtowns that require a flexible and temporary workforce for the uncertain sustainability of the oil resource (Davis, 2011). This workforce creates an increased housing demand for the town. The increased demand requires construction workers who also require living accommodations. Companies house their oilfield workers by renting out entire motel floors, purchasing mobile homes, or setting up "man camps", which are often groups of trailers (Davis, 2011). There are conflicting interests involved when deciding to transition from temporary to permanent facilities and infrastructure in boomtowns. On one hand, temporary lodging is ideal for rotational worker crews and nonresident workers who make up the temporary workforce and demand different quality-of-life amenities than resident workers (King, 2016). On the other hand, the sustainability of a host city or host nation (HN) after oil drilling subsides is dependent on the homeowners and families that become permanent residents and contribute to the local economy (Davis, 2011). With both approaches, the town requires a "*thoroughly composed development strategy to protect the community during [the] period of transition*" where the number of incoming workers exceeds the amount of living quarters (Davis, 2011, 9). This plan should accommodate the migrant worker's housing demand and focus on sustainable products and systems.

1.1.2. Temporary Post Disaster Assets

Natural disasters and armed conflicts often cause heavy damage to a local population's facilities and infrastructure. Throughout history, natural disasters, including (but not limited to) earthquakes and hurricanes, have displaced hundreds of millions of people leaving them without basic accommodations or satisfied psychological, social, and economical needs (Hayles, 2010). After Hurricane Katrina in 2005, over 947,000 families applied for housing assistance (El-Anwar, 2010). 211 million people were affected by natural disasters each year just from 2000 to 2010 (El-Anwar, 2010). Similarly to boomtowns, the application of temporary facilities and infrastructure post disasters offers local stakeholders fast results, temporarily satisfying their urgent needs while also affording an incremental and flexible approach toward typically long lasting reconstruction (Németh & Langhorst, 2014). Temporary shelters used post disaster include (but are not limited to) private homes, converted public and private facilities, or government-provided prefabricated buildings (Arlikatti, Andrew, Kendra, & Prater, 2015).

An issue faced by both employed military and post disaster assets is utilization for durations longer than originally anticipated. The prolonged use of temporary housing by families in close quarters reduces privacy, increases the probability of exposure over time to mold or toxins like formaldehyde, and potentially leads to increased psychological stress due to disaster trauma, relocation, heat, poor sanitation, and sometimes ethnic tensions (McDonald & Ovca, 2017; Arlikatti, Andrew, Kendra, & Prater, 2015; Zazar, Hagelman, Lavy, & Prince, 2017). FEMA trailers are used for temporary post disaster housing and are anticipated to be utilized for up to 18 months (Zazar, Hagelman, Lavy, & Prince, 2017). However, in Hurricane Katrina, FEMA trailers were used for up to 44 months. This led the US Congress to appropriate $400 million to the Department of Homeland Security in 2006 to fund an alternative housing program that would provide affordable and quickly constructed permanent housing to displaced persons post disaster (El-Anwar, 2010). Research in this area includes optimization models that maximize the social benefits gained by displaced persons from permanent housing while minimizing the associated investment costs (El-Anwar, 2010).

Some countries plan for the impact natural disasters have on their infrastructure and population, while others react after the devastation occurs. Timely decisions are required by stakeholders post disaster to provide clarity and organization. However, because of various reasons including pressure from the media or government agencies, reconstruction decisions are often made too hastily (Arlikatti, Andrew, Kendra, & Prater, 2015). For developed countries, while quick decisions and construction may satisfactorily accommodate disaster victims in the short term, this hastiness could prove problematic in the long term (Fischer & Carter, 2016). Tent cities, for example, that were rapidly constructed in an orderly manner after Hurricane Andrew in 1992 to meet the shelter needs of disaster victims, in hindsight, resembled Japanese internment camps instead of a supportive social environment (Arlikatti, Andrew, Kendra, & Prater, 2015). For developing countries, quick decisions post disaster combined with a lack of capital, education, and effective building standards result in communities reverting to familiar construction methods as opposed to alternative methods that support sustainability and limit future vulnerability (Fischer & Carter, 2016).

Countries that plan for how they will employ assets post disaster are better prepared to make cost effective and strategic decisions beneficial in the short and long term. The United States Coast Guard's coastal disaster plan, for example, includes deploying a damage assessment team (DAT) to assist in disaster response. Coast Guard DATs were deployed immediately after Hurricane Sandy in 2012 and Hurricane Arthur in 2014. The DATs conducted damage assessments and facility repairs ensuring safe infrastructure, including air stations, command centers, and housing units for service members. This enabled the Coast Guard to more effectively perform its Search and Rescue mission (Bachtel, Nakagawa, & Pierson, 2015).

Studies have similar terminology when addressing the phases for post disaster recovery starting with immediate and emergency relief and then transitioning to the longer-term reconstruction. During the immediate and emergency relief phase (Roseberry, 2008), or what one study refers as the response stage, debris are cleared, structures are made safe, emergency and temporary shelters are erected, and basic transportation, sanitation, communication and power systems are restored (Le Masurier, Rotimi, & Wilkinson, 2006). This phase also includes the rescuing of victims (Shaw & Goda, 2004). Disaster victims are not meant to remain in temporary facilities for long periods for physical and social reasons previously discussed. A transition to the longer-term recovery stage (Le Masurier, Rotimi, & Wilkinson, 2006) or reconstruction phase (Arslan, 2007) provides these victims an improved lifestyle with newly constructed or repaired permanent housing and services to aid in a return to normal daily life.

1.1.3. Decision Considerations

The presence of natural resource may drive an inflow of migrant workers, an increase in population, and a housing demand for boomtowns. "*Without proper* *development and planning, an oil boom community is at risk of an economic failure*" (Davis, 2011, 9). Disasters create housing demands as people are displaced from their homes. Communities that are vulnerable to natural and manmade disasters also need to be prepared with approved preventative plans that address the process to reconstruct the affected region and return the local population to normalcy (Arslan, 2007). Adequate pre-planning is imperative to ensure post-disaster decisions not only accommodate the immediate needs of the affected region but also account for the long-term sustainability of the built environment. For boomtowns and communities that are victims of disaster, solutions and investments executed without consideration for the long term can potentially lead to social problems and environmental degradation of the built environment. One social problem occurred after the earthquake in Kobe, Japan in January 1995 when the administration for housing approved a rehabilitation plan that was not affordable to many victims (Shaw & Goda, 2004). An environmental problem occurred in Aceh, Indonesia after the 2004 tsunami. Five-hundred thousand (500,000) people became homeless and 120,000 homes needed to be rebuilt. "*The high demand for local natural building materials, which [were] being mined, cut, and dredged in such a short amount of time, [had] impacts on ecosystems which might never recover*" (Roseberry, 2008, 3). Disaster plans should designate a site that can accommodate the construction of temporary facilities and infrastructure as necessary. Plans should also estimate amounts of inflicted damage, homeless people, and required supplies and materials, while being sensitive to the local needs and expectations with respect to culture and traditions, construction standards and work priorities (Félix, Monteiro, Branco, Bologna, & Feio, 2015).

1.2. MILITARY APPLICATIONS

The military base is fundamentally similar to a civilian city in that it has a population with basic physiological, safety, and social needs satisfied by the use of facility and infrastructure assets. Like boomtowns, disaster displacement, and countries taking in asylum-seeking migrants, bases at times accommodate rapid increases in population. Bases, like civilian communities, can be vulnerable to natural and manmade disasters. Despite all these similarities, what differs between the civilian and military sectors, besides definitions of construction standards as previously discussed, are the guidance and doctrine the military applies, the leadership chain enforced in the military, and the method in which assets are transitioned between construction standards. In order to understand how the military utilizes temporary and permanent assets, it is first necessary to understand how the military is organized, what capabilities military engineers possess, and the guidance that drives military decisions.

1.2.1. Organization and Capabilities

Joint Engineer Operations (2016) is doctrine that, in addition to construction standards, includes the organization and capabilities of military engineers, the three levels of planning, and considerations for the transition between construction standards. The US Military has strategically located bases throughout the world that are critical to accomplishing specific missions regarding "*major regional conflicts, small-scale contingencies, terrorist responses, or humanitarian relief operations*" (Snyder & Mills, 2004, 43). The SecDef or a Combatant Commander (CCDR) can designate a Joint Force, led by a joint force commander (JFC), to accomplish a functional or geographic mission. The JFC has a joint force engineer who is the lead engineer of the joint force. The joint engineering force that operates in deployed environments is made up of military engineers from the US and allied nations, US civilians, and HN engineers and contractors. Each of these actors contribute unique "*strengths, capabilities and availability*" to the joint force (Joint Engineer Operations, 2016, IV-26). Combined, this force establishes, develops, constructs, operates, maintains, and eventually decommissions bases. The joint force engineer, under the JFC, oversees the planning, execution and management of these tasks. (Joint Engineer Operations, 2016). The military engineer is "*a key enabler for flexibility and sustainment across all [US Military] Services and all types of operations. Military engineers also historically have been used across all phases of conflict from pre-deployment to engagement to post hostilities reconstruction*" (Niemeyer, 2002, 3). When establishing bases, military engineers are among the first on site. Their responsibilities include setting up airfields and providing life essential services, enabling additional forces to operate.

The joint engineering force has combat, general, and geospatial engineering capabilities to meet the JFC's requirements for the designated mission (Joint Engineer Operations, 2016). Each of these capabilities requires specific amounts of temporary and permanent assets. Combat engineering capabilities support the maneuver of land combat forces. Typically, Army and Marine engineers perform combat engineering and use temporary asset support. All services in the US Armed Forces perform general and geospatial engineering capabilities to an extent. Both types require combinations of temporary and permanent assets. General engineering capabilities include modifying, maintaining, and protecting the built environment. Geospatial engineering capabilities include terrain analysis and visualization of the operational environment. Military engineer capabilities, in response to natural or manmade disasters, include (but are not limited to) rubble and debris removal, water purification, emergency repair of wastewater and solid waste facilities, and maintenance and restoration of essential services, such as providing emergency shelter. Joint Engineer Operations (2016) describes in more detail the contributions and traditional roles each of the US Military services provide to the joint engineering force's capabilities.

1.2.2. Levels of Planning

Military operations, such as deploying forces, establishing and maintaining bases, and accomplishing missions require strategic, operational, and tactical planning. The military experiences the same benefits from planning as the civilian applications discussed previously. The goal when planning is efficient mission execution with a highly responsive and agile force that is "*ready, at the right place, at the right time, to meet operational objectives, [and] delivered with maximum efficiency, in the smallest footprint, with the least amount of "tail," to preserve limited resources*" (Niemeyer, 2002, I). "Tail" refers to the functions that support offensive military capabilities or "tooth." "Footprint" refers to all materiel, equipment, and personnel needed to support capabilities at the theater, base, and Unit Type Code (UTC) levels (Galway, Amouzegar, Hillestad & Snyder, 2002). Joint Engineer Operations (2016) details each level of planning's unique focus and specific considerations.

The strategic planning level of infrastructure development focuses on force generation, engineer support priorities, contingency basing selection and characterization, storage considerations, environmental considerations, engineer interoperability, and force protection. This is the highest military planning level and the focus is on "big picture" decisions for the entire force. Minute details are developed at the lower planning levels (Joint Engineer Operations, 2016). During strategic planning, decisions are made, such as base location, required mission capabilities or time-phased force deployment data (TPFDDs), required supporting units of capability or UTCs including manpower, material, and equipment, and lastly, capability delivery methods (Snyder & Mills, 2004).

Operational planning ensures adequate engineer capabilities are provided to accomplish combat, general, and geospatial engineering support requirements while focusing on prioritizing limited assets and mitigating risks. Engineers anticipate requirements and request capabilities to meet them. They also use geospatial data means to map proposed beddown locations and assist in developing plans for deployment, reception, employment, and sustainment. The operational planning level focuses on a specific region and its unique requirements. Tactical planning focuses on specific engineering tasks at the lowest level, the unit, to accomplish the JFC's objectives (Joint Engineer Operations, 2016).

At the **base** level, the master plan aids in decision making at the operational and tactical levels. The master plan "*prioritize[s] competing base camp assets*," such as facilities and infrastructure, "*distribute[s] limited resources in a way that best supports the mission, provide[s] a validated and synchronized road map for future development, and propose[s] projects to meet short and long-range plans*" (Miller, 2011, 10). **The assets on a base are constructed with an intended duration in mind and for a specific capability.**

The JFC includes in the master plan and engineer support plan (ESP) decisions on what assets are required at the base to accomplish the designated mission. "*The ESP should identify the overall facility requirements and summarize the existing US assets, HN support and multinational assets, and construction needed to satisfy those requirements,*" (Joint Engineer Operations, 2016, IV-8). The master plan and ESP are influenced by the environmental-baseline assessment and site characteristics including the condition of existing infrastructure (Marlatt, 2003).

Time and cost are limited resources when employing any asset during the establishment or improvement of a base. Therefore, the master plan and ESP prioritize the ability to use pre-existing buildings now over constructing new ones for use at a future time. Pre-existing and US-owned facilities are the highest priority followed by pre-existing HN facilities, and lastly, new construction. **When construction is necessary, different construction techniques and standards can be employed as directed by the JFC and depending on mission requirements**. When choosing a standard, parameters the JFC considers (but are not limited to) the base population, the intended duration of US occupancy, availability of resources, utilities and construction materials both local and imported, and existing political concerns for permanency. The JFC must decide whether new construction of permanent assets or alternatives such as temporary construction are appropriate. **Expeditious or rapid construction of temporary assets can be employed with minimum time, cost, and risk but involves a tradeoff in security, quality of life and overall maintenance costs** (Joint Engineer Operations, 2016).

Planning efforts are required to facilitate an eventual transition from temporary to more permanent facilities. "*Timelines provide a framework to plan for the transition of standards, but the actual trigger for transition will be based on conditions,*" (Joint Engineer Operations, 2016, IV-27). This study aims to understand the how construction standards are applied to facility assets and the extent application aligns with US Air Force intentions. This understanding can eventually aid future research on the conditions that contribute to the trigger for a transition of standards.

1.2.3. Construction Standards

The US military can deploy to established bases or to austere locations with the potential to become an established base. This potential is dependent upon a water source that can be made potable and area to establish an airfield. When these austere locations are utilized, they are known as bare bases (Snyder & Mills, 2004). Bare bases require supplies to be transported on site and an initial force that will secure and build up the area. Similarly to disaster victims, this initial force has basic needs such as safety, water, shelter, and food. US Air Force Civil Engineer Prime BEEF (Prime Base Engineer Emergency Force) and RED HORSE (rapid engineer deployable heavy operational repair squadron engineer) teams deploy with this initial force and set-up temporary services to satisfy these needs (Galway, Amouzegar, Hillestad & Snyder, 2002). Each of these teams have unique capabilities. Prime BEEF capabilities include (but are not limited to) infrastructure maintenance and repair, firefighting, emergency management services, explosive ordinance disposal, and CBRN defense. RED HORSE capabilities include (but are not limited to) heavy repair, general engineering and force beddown (Joint Engineer Operations, 2016, II-14).

Upgraded facilities, infrastructure, and construction standards may be warranted as bare bases develop into established bases accommodating an increase in population. Certain assets may require transition to more permanent standards, the base may require expansion, or new assets may need to be constructed. Facilities and infrastructure for basic needs must be scalable and flexible, especially in bare base environments because of the potential for changes in mission and the beddown of additional forces (Gealy, Long, & Soylemezoglu, 2012). "*The CCDR specifies the construction standards for facilities in the theater to optimize the engineer effort expended on any given facility while assuring that the facilities are adequate for health, safety, and mission accomplishment*," (Joint Engineer Operations, 2016, IV-27). Regardless of construction standard, the "*JFC must strike a balance between expediency, durability, and safety to meet mission requirements*," (Miller, 2011, 13). **Temporary assets may be less costly to construct and more expediently constructed, but they often cost more to maintain and provide a less desirable quality of life than semi-permanent and permanent assets.**

1.2.4. Considerations for Transition

The decision to transition between initial, temporary and semi-permanent or from a contingency location to an enduring location is made by the Geographic Commander, with approval by the SecDef, and in coordination with joint engineers at the strategic, operational, and tactical levels. **According to Joint Engineer Operations (2016), factors that must be considered in the decision to transition between construction standards include cost-effectiveness, the appropriateness of employing multiple standards to a single location, and the life-cycle sustainment requirements for upgraded assets**. The upgrade in standards must be justifiable and match the intended duration of use for the asset.

If a base is assigned multiple missions, some assets may be assigned a temporary standard while others have a more permanent standard. For example, if one portion of the base is designed to house transitioning personnel, temporary housing may be used, and if another portion is designed to house HN forces, permanent housing may be used to meet these requirements. Lastly, the sustainability requirements including manpower, maintenance, and HN capability must be considered. Individual assets need not transition through construction standards sequentially from organic to permanent. All assets on a base need not follow the same transition timeline. "*Power production facilities, for example, may follow a much quicker timeline than the facilities they support*," (Joint Engineer Operations, 2016, IV-31).

1.3. TRANSITION SPECIFIC RESEARCH

From literature (e.g., Oaks, Stafford, & Wilson, 2003; Roseberry, 2008) it is known that certain facility and infrastructure assets in the civilian and military sectors are intended to remain temporary, such as lodging for civilian temporary workforces and temporary military petroleum pipelines, while others transition to a permanent construction standard, such as post-disaster shelters and military fuel storage. Lodging used by "fly in fly out" workforces in remote mining locations, such as the Scottish and Norwegian oil fields, the Canadian mineral sands region, Africa, and remote and regional areas of Australia are intended to remain temporary (McKenzie, 2011). The uncertainty in the life of the resource and temporary nature of the workforce justifies investments in temporary assets.

The US Army's temporary petroleum pipelines installed to support short-term non-rotational fuel requirements for US land-based forces are intended to remain temporary. Non-rotational means the mission has a short duration and there will not be a future fuel requirement prompting construction of additional or more durable pipelines. Historically, aluminum piping and lightweight steel piping have been used for above-ground petroleum distribution systems. These systems have been employed seven times for short distances less than 25 miles long and only four times for medium and long distances over 50 miles since the Vietnam War. Since the systems are above ground, vulnerable to enemy attack, and are obstacles to troop maneuverability, the pipelines have not been maintained in place for long periods of time and shorter, more successfully defended distances have been most frequently employed (Oaks, Stafford, & Wilson, 2003). An example of assets from the civilian sector intended to transition to a permanent construction standard are the shelters for victims of the 2004 tsunami in Aceh, Indonesia. The shelters transitioned from temporary tents to semi-permanent timber housing and finally to permanent housing during the reconstruction effort to return the local population to normalcy (Roseberry, 2008). Finally, one example of an asset from the military sector intended to transition to a permanent construction standard is fuel storage. A bare base may initially employ temporary bladders, which can, when feasible and as the base transitions to enduring, be converted into sturdier above-ground steel tanks (AFPAM 10-219v5, 2012).

While it is known that certain civilian and military assets transition from temporary to permanent construction standards as described above, there is however, limited analysis on the conditions and factors associated with construction standards and the trigger for these assets to transition between standards. The limited existing research on the transition of assets, which may inform the understanding of the application of various construction standards, includes considerations involved in planning for and executing asset transitions, disconnects between asset management planning and asset management execution, limitations in asset data, and lastly, arguments for and against transitioning assets from temporary to permanent construction standards.

1.3.1. Asset Transition Considerations

The following are considerations involved in asset transitions in the civilian and military sectors as described in literature. Planning should anticipate contingencies, such as the displacement of a community due to a disaster, and consider the eventual transition of assets. Planning should incorporate flexibility to accommodate changes such as the assignment of a new mission. Sustainability must be a priority in master planning and execution of asset transitions by accounting for limited local resources, community outreach and changing mission requirements (Gealy, Long, & Soylemezoglu, 2012; Nottage, Corns, Soylemezoglu, & Kinnevan, 2015). The last planning consideration noted, as stated in military doctrine including Joint Engineer Operations (2016), is planning for the eventual turnover of assets to HN forces. The HN should participate in planning whenever possible (Jors, 2011; Lostumbo et al., 2013). Cultural and economic factors should be considered in the selection of construction techniques and material. In execution, sustainable, locally available materials, infrastructure, and construction techniques must be used to the maximum possible extent because the HN will eventually be responsible for maintaining the assets once they are turned over (Marlatt, 2003; Posch 2006; Jors, 2011). In Afghanistan in 2011, the constructed temporary facilities did not have life expectancies long enough for the HN to eventually use and the selected construction materiel was imported from the US and Europe instead of being procured locally. The HN could not satisfy maintenance requirements of anything constructed with this materiel (Jors, 2011).

1.3.2. Asset Management Planning and Execution Disconnects

There are some disconnects between asset management planning and execution. The execution of missions does not always go as planned. For example, during Operation Enduring Freedom, none of the bare bases became operational within the Air and Space Expeditionary Force's standard of five days from the deployment order. Bases took much longer to become established; Diego Garcia took 17 days and Jacobabad took 73 days to become operational (Wager III, 2003). As missions evolve, the military often remains in locations for longer than originally expected (Nottage, Corns, Soylemezoglu, & Kinnevan, 2015). Equipment and materials are at times, in practice, overused for purposes which they were not originally designed. For example, XFBKA, the UTC that includes billeting facilities intended to support a beddown at a bare base, was actually used to accommodate personnel at established bases and refugees in humanitarian operations (Galway, Amouzegar, Hillestad & Snyder, 2002).

1.3.3. Asset Data Limitations

A significant challenge in researching asset transitions is the limitations in historical and conditional data with respect to availability and accuracy. According to a study by Dr. Walter Posch (2006), a list of all US bases in Iraq and their respective permanency was not accessible. Dr. Posch (2006) created a list that classified bases as permanent depending on the following factors: facility durability, the base's ability to conduct military operations, proximity to main population centers, critical military infrastructure, and strategic civilian infrastructure. An analysis on the transition of assets cannot be conducted without first knowing the classification of a base's permanency or updated phase of transition. Furthermore, two additional studies noted that historical data and documentation on assets were incomplete and inaccurate (Snyder & Mills, 2004; Lepore, 2010). During a study to develop a planning tool that swiftly calculates manpower and equipment requirements to generate military capabilities, Snyder and Mills (2004) avoided using historical data for deployed sites. At the time of the study, information on asset quantities and conditions was poorly documented, assigned UTCs and TPFDDs did not adequately satisfy resource requirements, and lastly, changing operational capabilities of a site made matching specific TPFDDs to assets onsite difficult. Instead, the authors relied on interviews with senior non-commissioned officers and Air Force publications for data. Any study on asset transitions requires overcoming the challenges of acquiring and validating existing data.

1.3.4. Arguments on Transition

To the author's knowledge, there are few studies that discuss the transition of assets from temporary to permanent construction standards in the civilian sector (e.g., Arslan, 2007). In a study on post disaster temporary housing, Arslan (2007) argued that minimal cost and minimal energy consumption temporary houses constructed of recycled materials should be used in the short-term to accelerate the reconstruction process. Arslan also argued that constructing permanent houses as quickly as possible is integral for the affected region to return to normal. Permanent houses are more cost effective than temporary houses because of longer lifespans and lower maintenance and renovation costs (Arslan, 2007). These statements indicate support for employing efficient temporary shelters in the short term to maximize resource consumption for the reconstruction of more cost effective long-term permanent housing.

Few reports from the military sector (H.R. 1268, 2005; Report to Congress, 2008; Marlatt, 2003), to the author's knowledge, mention either the transition of assets from temporary to permanent construction standards or support a particular standard over the alternative. The first is the House of Representatives' Committee of Appropriations' statement in 2005 (H.R. 1268, 2005) and the second is the Department of Defense's (DoD) internal policy in 2008 (Report to Congress, 2008). These two studies had contrasting expectations on the use of temporary assets for the military; the former supported temporary as the priority construction standard, while the latter supported swiftly transitioning temporary assets to permanent. The Committee on Appropriations, while realizing some permanent facilities are required to support an enduring presence, expects temporary facilities to be the rule and not the exception (H.R. 1268, 2005, 35). On the other hand, the 2008 US Army report highlighted an internal DoD policy requiring temporary facilities to be used only as an interim solution and to be swiftly replaced by permanent facilities. The report warned that the overuse of temporary facilities could lead to considering non-permanent facilities as acceptable living standards (Report to Congress, 2008). As compared to permanent facilities, non-permanent facilities are not as sturdy, durable, or secure from the elements or enemy attack (Report to Congress, 2008).

A third study argued conventional military semi-permanent construction in deployed environments "*takes too long, costs too much, and ties up critical transportation resources*," (Marlatt, 2003, 39). For example, the Southeast Asia hut, a semi-permanent facility used to house soldiers, requires large quantities of construction materials and create a large logistics "tail." While this report does not necessarily support temporary construction over semi-permanent or permanent construction, instead, there is an emphasis on the challenges associated specifically with semi-permanent construction. The report proposed a decision support management tool that provides "*better designed contingency facilities faster, with less logistics tail and a smaller footprint, and at the lowest cost to ensure the soldiers' comfort, health, safety, and combat readiness,*" (Marlatt, 2003, 41).

Despite having opposing stances on the priority construction standard, the two aforementioned military sector reports are similar in that they each either have an assumption or an acknowledged goal related to the construction objectives provided by Marlatt's (2003) management tool. The Committee of Appropriations' assumption of an expeditionary nature of efforts relates to the small footprint objective. The US Army report's argument that permanent facilities provide a solution secure from the elements and enemy attack relates to the objectives of comfort, health, safety and combat readiness.

1.4. DEPARTURE POINT

Despite significant contributions from reviewed studies on the use of temporary facility and infrastructure assets for temporary workforces, post disaster recovery efforts, and military applications, there is limited research on the conditions and factors that impact the decisions for various construction standards. This study seeks to understand how the US Air Force applies temporary, semi-permanent, and permanent construction standards to facility assets at two overseas military bases classified as transitioning from expeditionary to enduring.

There are many uses of temporary assets in the civilian sector, including (but not limited to) supporting peripatetic workforces and victims that have been displaced due to natural or manmade disasters. Decisions made by local and governmental authorities on the efficient employment of these assets for either of these civilian sector uses requires adequate pre-planning and consideration of the (1) local population's needs and expectations, (2) environmentally sustainable practices with regard to the use of building materials and construction techniques, and (3) the feasibility of asset beddown locations and durations. After a disaster, assets are constructed, utilized temporarily, and transitioned to more permanent construction standards as the community progresses through the post-disaster recovery cycle.

In military applications, assets are used to support deployed personnel living and working on strategically located established or austere bases throughout the world. The missions of these bases can include managing conflicts, contingencies, terrorist responses or humanitarian relief (Snyder & Mills, 2004). Each mission and set of personnel require specific amounts of temporary, semi-permanent, and permanent assets. The JFC establishes asset requirements for the base and considers asset transitions when possible as conditions allow according to the master plan and ESP. To meet facility and infrastructure system asset requirements, the JFC must decide on the appropriate construction standard taking into consideration the expeditious construction tradeoff that sacrifices security, quality of life, and overall maintenance costs for decreased construction time, cost, and risk (Joint Engineer Operations, 2016). Regardless of construction standard, the "*JFC must strike a balance between expediency, durability, and safety to meet mission requirements*," (Miller, 2011, 13).

A review of the limited research on the transition of assets yielded five findings. Firstly, certain civilian and military assets are intended to remain temporary while others transition to permanent construction standards. Secondly, there are defined factors to consider when transitioning assets in the civilian and military sectors including (but not limited to) anticipated effects of contingencies and the eventual turnover of assets to HN forces. Thirdly, in the military, asset management doctrine and plans are not necessarily what is executed in practice. Bases and assets are operated for longer durations and for different purposes than originally expected. Fourthly, there are limitations in historical and conditional asset data availability and accuracy. Lastly, various studies argue for and against transitioning assets from temporary to permanent construction standards. These five findings on the transition of assets may contribute to the trigger of asset transition and better inform an evaluation of how temporary, semi-permanent, and permanent construction standards are applied on military bases. This study seeks to fill the gap of previous research by determining:

- The extent which established construction standard definitions align with in-practice execution at military bases in terms of prioritization, construction, and maintenance investments. This specifically considers the classifications of permanent, semi-permanent, and temporary construction standards for facilities and infrastructure, while considering a base's characteristics (e.g., classification, unique composition, age, and mission).
- If asset data from military bases support either of the contrasting policies from the Committee of Appropriations and Department of Defense on the use of permanent facilities versus temporary facilities (H.R. 1268, 2005, 35; Report to Congress, 2008).

From an asset management perspective, this study's findings may be useful in both the civilian and military sectors, to better guide future planning assumptions and increase the extent that execution meets the designed intent. This study's findings, through the use of cost effective and risk-based decisions, may also help to transition post disaster communities through the disaster recovery cycle or bare bases to established bases more efficiently.

2. METHODOLOGY

2.1 Case Studies

This research included two case study analyses in Southwest Asia, Base A and Base B. Below are descriptions of each base.

2.1.1. Base A

Base A is located in Country A. Country A is approximately 4,500 square miles in size, has a terrain that is mostly flat and barren desert, and summer temperatures exceeding 120 degrees Fahrenheit. Base A was established in 1992, is about 12 square miles in size and has a population of about 6,000 military and civilian personnel. Base A’s mission is to protect US and NATO interests in Southwest Asia. The Base is currently transitioning from expeditionary to enduring.

There are four main US exclusive areas at Base A. Northeast Ramp/Operations Town (NE Ramp/OT) houses the flying and maintenance squadrons and the airfield. Log Town is approximately 250 acres and is used for Engineering, Communications, and Logistics squadrons and storage. Blatchford Preston Complex/Coalition Compound (BPC/CC) is approximately 640 acres and is used for support functions, supply warehouses and lodging. The last US exclusive area is the Munitions Storage Area (MSA). This area is used to store different types of munitions (e.g. small arms ammunition, missiles, and guided bombs). Throughout the base, administrative facilities are typically prefabricated modular buildings. Warehouses and Engineering shops are pre-engineered buildings, K-spans, and tents. The permanent construction method, which is prominent in BPC and NE Ramp, is cast-in-place concrete and masonry construction. While the temporary facilities in Log Town are reaching the end of their useful lives and some facilities in BPC are transitioning to permanent, the current focus for Base A is on transitioning the facilities in NE Ramp from temporary to permanent (Base A Master Plan, 2015).

2.1.2. Base B

Base B is located in Country B. Country B is approximately 11,060 square miles in size, has a terrain that is mostly flat and undulating desert sand, and summer temperatures exceeding 122 degrees Fahrenheit. Base B was established in 1990, is approximately 5 square miles in size and has a population of approximately 1,000 military and civilian personnel. Base B's mission is to deliver decisive airpower, theater basing options and theater logistical support in line with USAFCENT priorities. The profile of existing facilities reflect the contingency type mission Base B had during Operation Iraqi Freedom. While the Base has transitioned over the last decade from expeditionary to enduring, temporary facilities, such as tents and relocatable facilities, will still be required to accommodate population fluctuations and changes in mission.

There are three main US exclusive areas at Base B. The Rock is used for lodging, administrative functions including Wing headquarters, financing, contracting, and the passenger terminal and support and service functions including but not limited to the post office, chapel, theater, shopping areas, barber shop, and gymnasium. The airfield houses the flying and maintenance squadrons, and facilities that support the tactical airlift mission. The last US exclusive area is the Munitions Storage Area (MSA). Throughout the base, the existing facilities are a mix of expeditionary and enduring construction. Some facilities at The Rock and the airfield were previously owned by the host nation and the other facilities including prefabricated, CMU, metal panel and tent facilities were constructed by the US (Base B Master Plan, 2015).

2.2. DATA

The data for each base is from two sources: (1) Real Property spreadsheets currently used at each location and (2) facility reports from a database called BUILDER, which was initially populated by the US Army Corps of Engineers in 2015 and has had limited updates since. These sources include data on each of the two Air Bases' asset history and conditions, such as construction completion dates, descriptions of facility functions and users, construction types, facility locations, cost basis, improvement dates and expenses, criticality to the mission, and facility health.

Three categories of data were used from these sources, specifically complimentary data, assumed data, and exclusive data. First, complimentary data between the two sources, such as a facility that has matching areas according to both sources, were considered valid and included for the dataset used for analysis. Second, for instances when data between the two sources indicated the existence of a facility, but specific information conflicted (e.g. different total area assignments for the same facility), the Real Property spreadsheet data was used. The Real Property spreadsheets were assumed to be more accurate because they were more updated than the BUILDER reports. This was confirmed anecdotally with Air Force Engineers who were at the time deployed to US Air Bases in Southwest Asia. Lastly, unique facility and infrastructure data from each source was included; this type of data was primarily from the Real Property spreadsheets. The focus for this study was on the construction standards of facilities. Equipment and pavement data from the two sources were excluded from the sample, as well as facilities that were not classified with a construction standard of permanent, semi-permanent, or temporary.

The final usable sample dataset was preprocessed in various ways. In instances when areas would be listed multiple times because a single facility housed multiple category codes (CATs - which are description of a facility's scope and function; a list of analyzed CATs and their definitions is included in the Glossary), the researcher ensured the area was only counted once. Outliers in total area, cost basis, and expensed improvement were identified and either corrected or eliminated. Construction standards when lacking were assigned if a facility matched a similar facility by factors such as CAT, description, year completed, or total area. Units of measure were standardized (i.e. area in square feet). Lastly, Mission Dependency Indexes (MDIs – facility importance metric on a scale from 0 to 100 where 100 corresponds to facilities most important to the base's mission), were assigned when lacking if a facility matched a similar facility by construction standard, CAT, and total area +/- 25%. It is important to note that 210 facility MDIs for Base B were added to the usable dataset, bringing the total facilities with MDIs in the sample from 50% to 95%. Originally, the 210 MDIs were unpopulated in the two sources. However, each of the 210 facilities individually shared multiple of the aforementioned characteristics with other facilities and thus, it was reasonable to assume MDI was also similar. Building Condition Indexes (BCIs) measure from 0 to 100 the condition of a facility, where 100 corresponds to perfect health.

Table 2.1. Bases A and B Data Summary

	Base A	**Base B**
Total Facilities	816	465
Facilities with MDIs	816 (100%)	444 (95%)
Facilities with BCIs	690 (85%)	223 (48%)
Facilities with both MDIs and BCIs	690 (85%)	219 (47%)
CATs with facilities of all three construction standards: permanent, semi-permanent, and temporary (PST CATs)	Airfield, Civil Engineering, Logistics Readiness Squadron, Fire Pro, Sanitation, Security, Services	Airfield, Civil Engineering, Explosive Ordnance Disposal, Lodging, Maintenance, Dormitory Visiting Airmen Quarters, Security, Services, Water

The limitations for this research are associated with the accuracy of the source data and the challenges that come with the distance from case study locations. While preprocessing data, there was evidence of human error, likely due to manual entries for the population of databases. For example, the largest facility in the sample has a cost basis of only $100,000 while absolute largest cost basis was $7,000,000. The sources for the sample data are current as of July 2017. At that time, there were efforts to inventory and assess the condition of every facility on each of the two bases; therefore, the findings for this study may only reflect characteristics of each base at a previous point in time.

2.3. HYPOTHESIS TESTING

This research included two types of hypothesis testing: Chi-Square Test for Independence and Analysis of Variance. Multiple categorical and quantitative variables were assessed for each base to understand their relationships, how these relationships compare between the bases, and if the relationships in practice align with the intentions of US Air Force leaders. Identifying differences between bases and differences between asset management planning and execution could help drive behavior changes and better inform decisions at the strategic, operational, and tactical planning horizons.

2.3.1. Chi-Square Test of Independence

The variables from the usable dataset include: Construction Standard, CAT, PST CATs, Area, Cost Basis, Expensed Improvements, Age, Past Intended Age, MDI, BCI, and Location. Matrices were formed for Bases A and B to represent all possible pair-wise combinations of variables from the usable dataset. The Chi-Square Test of Independence was used to determine if statistical relationships exist among these combinations. The null hypothesis for each combination was that the pair of variables is independent.

2.3.2. Analysis of Variance with Post Hoc Tukey HSD

The one-way analysis of variance (ANOVA) was used to compare variance of construction standard means at the **category code**, **location**, and **base** levels. At the **CAT** and **Location** levels, variance in mean Age, BCI, and MDI[1] were analyzed between construction standards within particular CATs and Locations. At the **base** level, variance was analyzed between individual construction standards across CATs and Locations. Each ANOVA result table reveals grouping designated by one or more letters. Within each group, there are no statistically significant differences. The groupings start with the letter "A." The final group not only indicates a result that is significantly different from the "A" group, but it also gives an understanding of the number of different possible groups there are. For example, there are more possible groupings between groups "A" and "Z" than between groups "A" and "D."

At each level, this study sought to determine if there are any statistically significant differences between each group's means. For example, one ANOVA was conducted at the **CAT** level for the Civil Engineering (CE) category code (as shown in Table 3.8.), comparing mean MDIs between three facility groups: permanent (P), semi-permanent (S), and temporary (T).

A post hoc test, the Tukey honest significant difference test, was used to correct for Type I error. The null hypothesis for each test was that the mean for each group is statistically equivalent. For the ANOVA tests, the researcher focused on category codes whose facilities are of all three construction standards (i.e. PST CATs). Age, BCI, MDI, Construction Standard, CAT, Location, and Past Intended Age were selected for ANOVA to understand how each base prioritizes and maintains its facility and infrastructure assets. Area and Cost Basis were not considered as it is expected that facilities of different

[1] MDI was analyzed at the CAT and Base Levels but not at the Location Level

construction standards and on different sized bases will also vary in size and in turn, construction and acquisition costs.

3. RESULTS AND DISCUSSION

Acronyms

BCI	Building Condition Index (0 to 100 - poor condition to excellent condition)
CAT	Category Code - Designator of a facility's scope, requirements, and general function (e.g., Airfield - Buildings that directly support the airfield including housing for radar approach control systems, EOD personnel and equipment, sunshades, and Fuel personnel)
MDI	Mission Dependency Index (0 to 100 - low importance to high importance)
PST CATs	Category codes that have facilities of all three construction standards (permanent, semi-permanent, and temporary)

Analysis Levels

CAT Level	Analysis of permanent, semi-permanent, and temporary facilities *within* a particular category code
Location Level	Analysis of permanent, semi-permanent, and temporary facilities *within* a particular location
Base Level	Analysis of a particular construction type across all category codes or across all locations

The following section includes the results and discussion of three separate analyses: base characteristic comparisons focusing on construction standard proportions, MDI, BCI, and Age; Chi-Square test for independence; and ANOVA at the **category code**, **location**, and **base** levels.

3.1. BASE CHARACTERISTICS

The following section focuses on the characterization of each base's composition, in terms of the presence of each construction standard, proportions of high, medium, and low importance and conditions of facilities, and whether facilities are within or past their originally intended ages. The intended lifespan for semi-permanent facilities is 10 years and 5 years for temporary facilities.

The first step in understanding the role that construction standards play is to define each construction standard's presence on each base. Figure 3.1 illustrates construction standards by facility count and total facility area. By count, a majority of facilities on Base A are semi-permanent; however, by total facility area, permanent facilities occupy approximately four times the space relative to semi-permanent facilities. For Base B, while by count, there are more temporary facilities than either permanent or semi-permanent, by total facility area, semi-permanent facilities occupy a majority of the space at approximately over 7.5 times the area of temporary facilities. A breakdown by area provides a more accurate representation of each construction standard's presence on the two bases and an indication as to how far along in the transition to enduring each base may be. Base A, which by area is approximately 77% permanent construction, may be farther along in transitioning to enduring than Base B, which by area is only about 28% permanent construction.

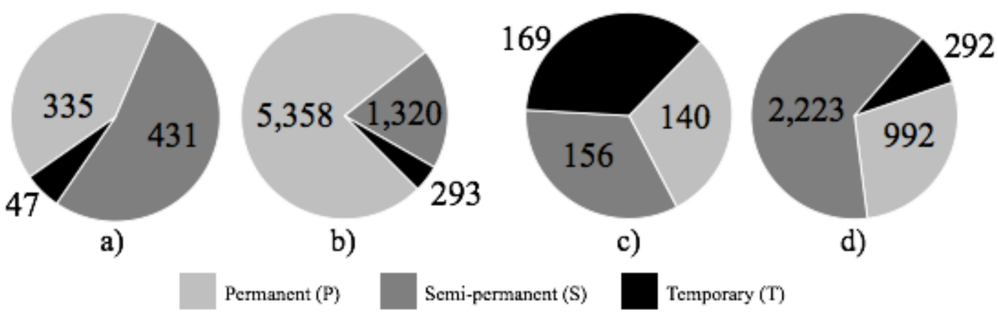


Figure 3.1. Facility construction standards: (a) Base A facility count; (b) Base A total facility area (000 sf); (c) Base B facility count; and (d) Base B total facility area (000 sf)

With regard to MDI, breakdowns of construction by count and area yield similar proportions of low, medium, high, and unknown MDIs for both bases. Figure 3.2 shows that Base A, which is over twice the size of Base B, has a larger ratio of Medium MDI to High MDI facilities than Base B. The prioritization composition of Base B, where a majority of the facilities are of high importance and almost no facilities are of low importance, is unexpected because this means essentially all facilities are important. This prioritization composition may not be helpful in deciding where to invest limited resources. While MDI may play a role in investment decisions at Base A, these decisions may be driven by other factors at Base B.

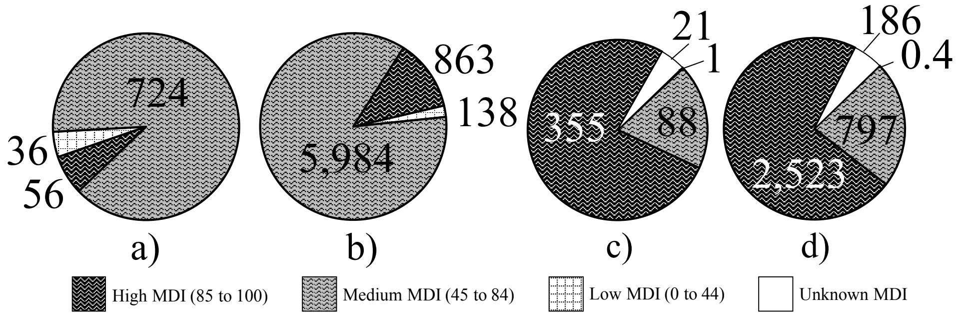


Figure 3.2. Mission Dependency Index (MDI): (a) Base A facility count; (b) Base A total facility area (000 sf); (c) Base B facility count; and (d) Base B total facility area (000 sf)

With regard to facility conditions, the breakdown of construction by count and area also yield similar compositions for Bases A and B. Figure 3.3 shows that from what is known, both bases are overall in good to excellent condition (BCI > 44) and almost no facilities are in poor condition (BCI ≤ 44); this is significant for Base B, considering the large number of high importance facilities.

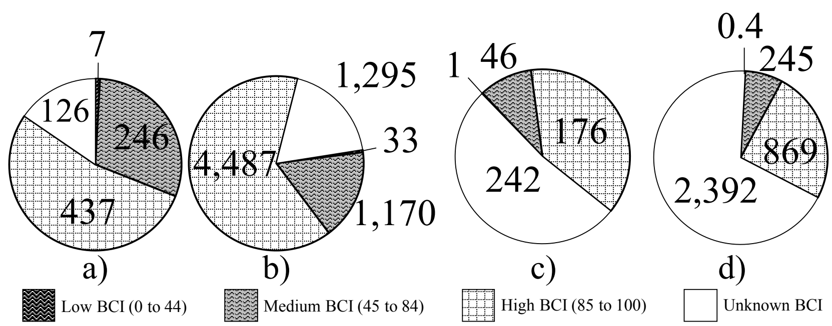


Figure 3.3. Building Condition Index (BCI): (a) Base A facility count; (b) Base A total facility area (000 sf); (c) Base B facility count; and (d) Base B total facility area (000 sf)

By count, Figure 3.4 shows both bases have approximately the same number of permanent, semi-permanent, and temporary facilities within their originally intended ages (10, 10, and 5 respectively)[2], as facilities past their originally intended ages. Figure 3.4. also shows that the most important facilities (MDI >84) that are within or past their originally intended ages are in good to excellent condition. Interestingly, for both bases there are approximately the same number of high MDI facilities that are within their intended age as past. Lastly, Figure 3.4 indicates that at Base A, 73 medium importance facilities past their intended age have unknown conditions and at Base B, 120 high importance facilities past their intended age have unknown conditions. This is concerning for Base B, which should either reprioritize its facilities to provide clarity on where it is taking risk by not knowing conditions, or assuming the current prioritization is correct, increase efforts to update inventory by assessing conditions especially for the high importance facilities past their intended ages.

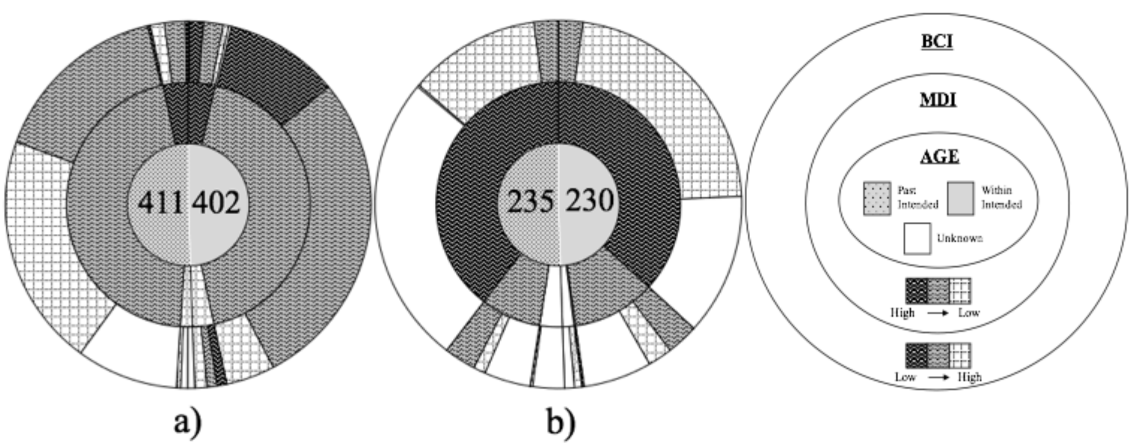
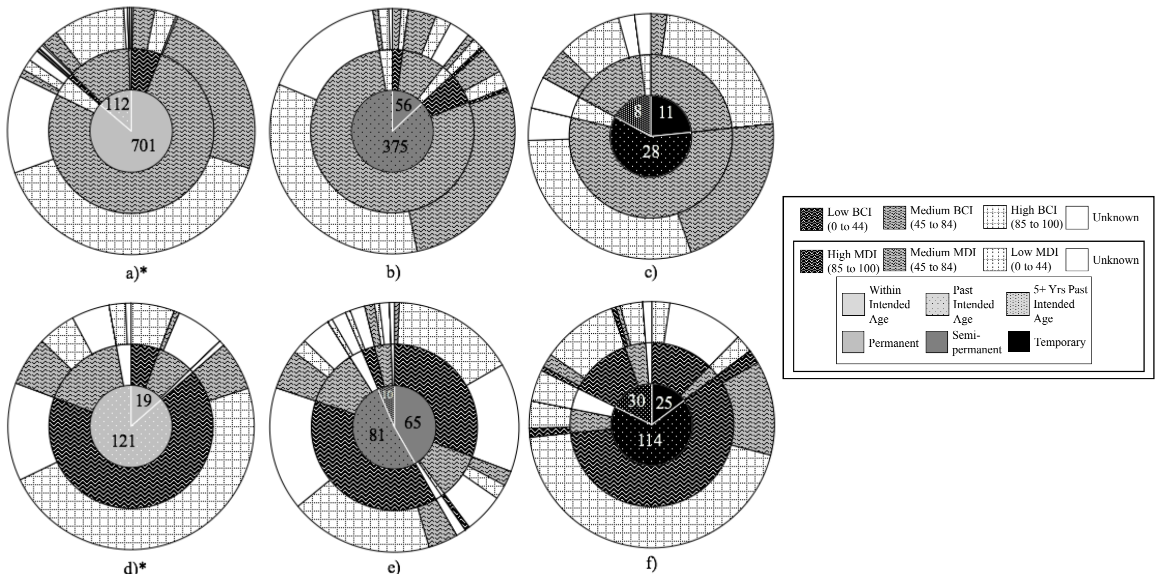


Figure 3.4. Facilities overview by Age, MDI, and BCI: (a) Base A and (b) Base B

[2] All permanent facilities, which are intended to be used past 10 years, were included in the "within" category for Figures 3.4.

For both bases semi-permanent and temporary facilities are being used past their originally intended life, according to Figure 3.5; however, less than 25% exceed five years past their originally intended life. Of those, regardless of MDI, a majority are in good to excellent condition. A concern of interest for Base B, granted the data is as of July 2017, is the number of high MDI semi-permanent facilities past their intended age whose condition is unknown (28 unknown v 62 known). Fortunately, most of the conditions for facilities past their intended life are known, and the facilities with unknown **BCIs** are likely similar in condition to the rest of the base which has an average BCI of 87.4.

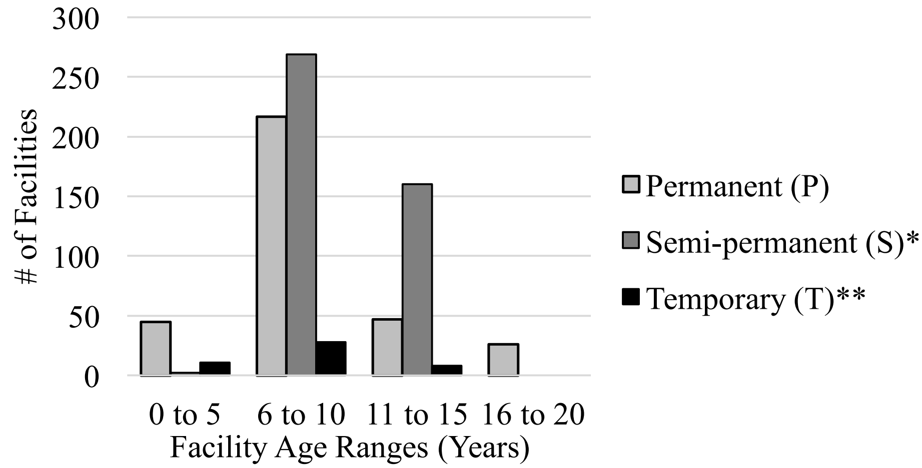
Interestingly, the ratio of facilities within to past their originally intended age (Figure 3.5) corresponds with the ratio of permanent to semi-permanent facility areas (Figure 3.1) for each base. Base A, which has a larger ratio of permanent to semi-permanent facilities, also has a larger proportion of permanent facilities under 10 years than Base B. Base B, which has a larger ratio of semi-permanent to permanent facilities, also has a larger proportion of semi-permanent facilities under 10 years than Base A. Considering both bases were established only two years apart (Base A in 1992 and Base B in 1990), Base A's data may be limited because the earliest construction date is 2000 as opposed to 1990 for Base B.



**Past Intended Age for permanent facilities represents facilities over 10 years old. Permanent facilities are intended to be used for over 10 years.*

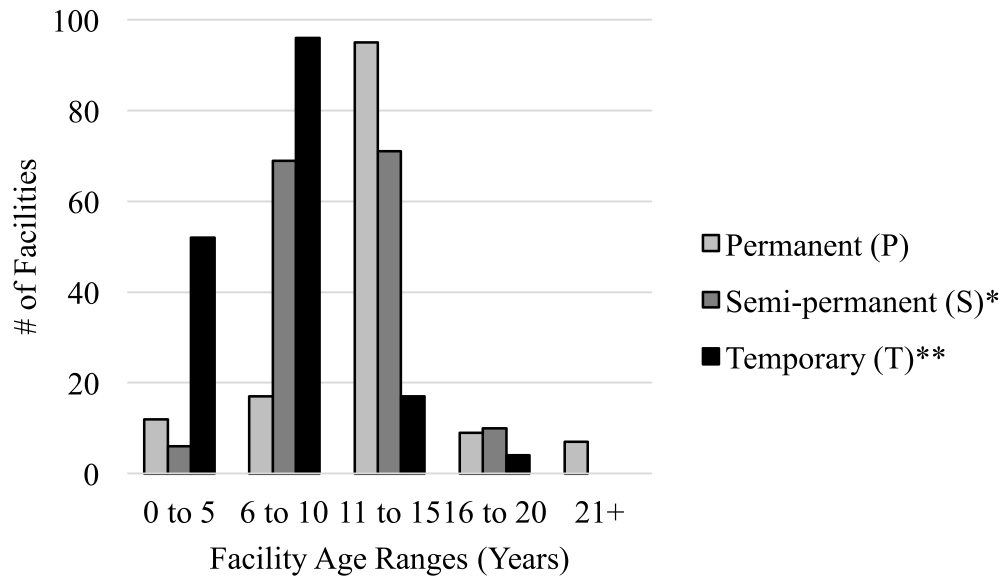
Figure 3.5. Overview by Age, MDI, and BCI: (a) Base A permanent facilities; (b) Base A semi-permanent facilities; (c) Base A temporary facilities; (d) Base B permanent facilities; (e) Base B semi-permanent facilities; (f) Base B temporary facilities

Figures 3.6 and 3.7 show the breakdowns of permanent, semi-permanent, and temporary facilities by age at Bases A and B respectively. Like the previous figures, these figures show that while there is a significant number of semi-permanent and temporary facilities past their originally intended ages, a majority have only surpassed their intended age within the past five years. Furthermore, a majority of facilities greater than 10 years in age are semi-permanent and permanent. This could be an indication that both bases are prolonging the operations and maintenance of facilities in support of a more enduring presence. Interestingly, there are multiple temporary facilities at both bases that are twice their originally intended ages. This finding reveals that construction standards are not limited to intended durations of use. The standards may be used to portray a temporary presence despite occupying the base for over 25 years.



**Semi-permanent facilities over 10 years are past their originally intended age*
***Temporary facilities over 5 years are past their originally intended age*

Figure 3.6. Base A Facility Ages by Construction Standard



**Semi-permanent facilities over 10 years are past their originally intended age*
***Temporary facilities over 5 years are past their originally intended age*

Figure 3.7. Base B Facility Ages by Construction Standard

3.2. CHI-SQUARE TEST FOR INDEPENDENCE

Tables 3.2 and 3.3 explore the relationships between categorical and quantitative variables in the data. The matrices show p-values for each variable pair combination and whether the variables are related at the 90%, 95%, and 99% confidence levels. There were 17 pairwise Chi-Square tests with differing results between Bases A and B, as shown on Table 3.1 The variables that differed the most in relationships between the two bases included **BCI**, **Area**, and **Expensed Improvements**. The application of these variables to construction standards differs between the bases.

Table 3.1. Inconsistent Chi-Square results between Bases A and B

Dependent Variable Pairs for Base A that were not related for Base B	Dependent Variable Pairs for Base B that were not related for Base A
• Construction Type and Area • Construction Type and BCI • Category Code and Area • Category Code and BCI • Area and Expensed Improvements • Area and Past Intended Age • Area and MDI • Expensed Improvements and Past Intended Age • Expensed Improvements and MDI • Expensed Improvements and Location • Past Intended Age and BCI • MDI and Location • BCI and Location	• PST Categories and Cost Basis • PST Categories and Expensed Improvements • PST Categories and BCI • Cost Basis and BCI

While there are similarities between both bases regarding the relationships with variables and **Expensed Improvements**, the data for **Expensed Improvements** was limited in each base's sample. The conclusions drawn from these particular results are therefore suspect; for example, in both bases, **Age** and **Expensed Improvement** are unexpectedly independent; however, it would make sense that a relationship exists where expensed improvement increases with age.

An interesting finding is that while at Base A, all variables (**CAT**, **PST CATs**, **Area**, **Cost Basis**, **Expensed Improvements**, **Age**, **Past Intended Age**, **MDI**, **BCI**, and **Location**) are related to construction standard, at Base B, all variables *except* **Area** and **BCI** are related to construction standard. **Past Intended Age** is the variable indicating whether semi-permanent and temporary facilities have exceeded their originally intended age. With regard to **Area**, a relationship is expected where generally permanent facilities have larger areas than temporary. Upon further investigation, about 96% of the sample facilities at Base B are under 20,000 sf and the remaining 4% ranges from 20,000 to almost 470,000 sf; area for facilities under 20,000 sf and construction standards are related at Base B, as expected. **BCI** may not be related to construction standards at Base B, because maintenance decisions may be driven instead by other factors such as a facility's **CAT** (for PST CATs), **Cost Basis**, **Age**, and **MDI**.

Interestingly, for both bases, **Past Intended Age** is related to **Construction Standard**, **CAT**, and **Location,** but has no relationship to **MDI**. Therefore, semi-permanent and temporary facilities are being used for durations past their intended age depending only on specific category codes and locations and not how important each facility is to the mission. This finding supports the notion that both bases are avoiding the appearance of permanency by exceeding ages in facilities instead of replacing at least the most important ones with upgraded constructions standards.

At Base A, maintenance practices as indicated by facility condition, facility prioritization, and decision making on facility ages seem to transcend **CAT** or **Location**, while at Base B, these variables may be applied in different ways for different category codes and locations. This is expected as Base A is over twice Base B's size.

Table 3.2. Chi-Square Test results for Bases A

Base A	Const Standard[1]	CAT[2]	PST CATs[3]	Area[4]	Cost Basis[5]	Expensed Improvements[6]	Age[7]	Past Intended Age[8]	Importance (MDI)[9]	Condition (BCI)[10]	Location[11]
Const Standard		$p < 0.01$	$p < 0.01$	$p < 0.01$	$p < 0.01$	$p < 0.05$	$p < 0.01$	$p < 0.1$	$p < 0.01$	$p < 0.01$	$p < 0.01$
CAT	2.60E-90			$p < 0.01$	$p < 0.01$	$p < 0.1$	$p < 0.01$	$p < 0.01$	$p < 0.01$	$p < 0.01$	$p < 0.01$
PST CATs	3.50E-07			$p < 0.05$	–	–	$p < 0.01$	$p < 0.01$	$p < 0.01$	–	$p < 0.01$
Area	2.80E-08	2.2E-08	0.0307		$p < 0.01$	$p < 0.01$	$p < 0.01$	$p < 0.01$	$p < 0.01$	–	$p < 0.01$
Cost Basis	0.0003	1.20E-104	0.4048	1.40E-241		$p < 0.01$	$p < 0.01$	$p < 0.05$	$p < 0.01$	–	$p < 0.05$
Expensed Improvements	0.0118	0.0829	0.7983	1.10E-27	3.10E-16		–	$p < 0.01$	$p < 0.01$	–	$p < 0.01$
Age	8.30E-65	2.90E-64	3.40E-05	2.30E-06	5.50E-06	0.3277		$p < 0.01$	$p < 0.01$	$p < 0.01$	$p < 0.01$
Past Intended Age	0.0509	1.70E-35	4.50E-05	2.10E-08	0.0349	0.006	2.70E-96		–	$p < 0.01$	$p < 0.01$
Importance (MDI)	0.0038	1.20E-130	2.60E-23	4.20E-05	0.003	2.80E-05	0.0065	0.487		$p < 0.01$	$p < 0.01$
Condition (BCI)	0.0012	2.30E-06	0.1072	0.7471	0.9222	0.7467	2.90E-06	0.0001	1.40E-06		$p < 0.01$
Location	1.20E-75	4.80E-275	3.30E-40	5.70E-160	0.0149	5.80E-11	1.50E-110	1.80E-67	9.00E-26	5.00E-16	

[1]Construction Standard – Permanent, Semi-permanent, or Temporary; [2]Category Code; [3]Category Codes with facilities of all three construction standards; [4]Total facility area (sf); [5]Cost Basis – Construction and acquisition costs plus improvement costs over the capitalization threshold; [6]Expensed Improvements – Improvement costs below the capitalization threshold; [7]Age – Years since construction completion; [8]Past Originally Intended Age – Semi-permanent facilities over 10 years and temporary facilities over 5 years; [9]Mission Dependency Index – Measure of consequence of failure; [10]Building Condition Index- Measure of condition and weighted replacement value; [11]Location – Area designations within the base

Table 3.3. Chi-Square Test Results for Base B

Base B	Const Standard[1]	CAT[2]	PST CATs[3]	Area[4]	Cost Basis[5]	Expensed Improvements[6]	Age[7]	Past Intended Age[8]	Importance (MDI)[9]	Condition (BCI)[10]	Location[11]
Const Standard		$p < 0.01$	$p < 0.01$	–	$p < 0.01$	$p < 0.1$	$p < 0.01$	$p < 0.01$	$p < 0.01$	–	$p < 0.01$
CAT	1.80E-20			–	$p < 0.01$	$p < 0.01$	$p < 0.01$	$p < 0.01$	$p < 0.01$	–	$p < 0.01$
PST CATs	1.60E-06			$p < 0.01$	$p < 0.05$	$p < 0.01$	$p < 0.01$	$p < 0.01$	$p < 0.01$	$p < 0.01$	$p < 0.01$
Area	0.2613	0.819	0.001		$p < 0.01$	–	$p < 0.01$	–	–	–	$p < 0.01$
Cost Basis	0.0021	4.70E-65	0.0479	0.0004		$p < 0.05$	$p < 0.01$	$P < 0.1$	$p < 0.05$	$p < 0.01$	$p < 0.01$
Expensed Improvements	0.0932	0.0003	5.80E-05	0.9998	0.0192		–	–	–	–	–
Age	1.50E-33	4.80E-20	1.50E-05	0.0002	5.20E-85	0.9906		$p < 0.01$	$p < 0.01$	$p < 0.05$	$p < 0.01$
Past Intended Age	2.90E-50	6.60E-05	0.0006	0.1662	0.0594	0.3598	2.70E-09		–	–	$p < 0.01$
Importance (MDI)	0.0047	4.40E-29	5.00E-17	0.725	0.029	0.3924	5.00E-05	0.4258		$p < 0.01$	–
Condition (BCI)	0.1859	0.9166	0.0008	0.3349	7.70E-07	0.8354	0.0251	0.4448	6.30E-27		–
Location	7.90E-08	1.40E-39	3.70E-31	5.40E-18	1.30E-07	0.9999	9.80E-40	2.60E-05	0.1449	0.1992	

[1]Construction Standard – Permanent, Semi-permanent, or Temporary; [2]Category Code; [3]Category Codes with facilities of all three construction standards; [4]Total facility area (sf); [5]Cost Basis – Construction and acquisition costs plus improvement costs over the capitalization threshold; [6]Expensed Improvements – Improvement costs below the capitalization threshold; [7]Age – Years since construction completion; [8]Past Originally Intended Age – Semi-permanent facilities over 10 years and temporary facilities over 5 years; [9]Mission Dependency Index – Measure of consequence of failure; [10]Building Condition Index- Measure of condition and weighted replacement value; [11]Location – Area designations within the base

3.3. ANALYSIS OF VARIANCE

Analyzed Category Codes

Airfield	Buildings that directly support the airfield including housing for radar approach control systems, EOD personnel and equipment, sunshades, and Fuel personnel
CE	Civil Engineering facilities
EOD	Explosive Ordnance Disposal facilities
Lodging	Billeting facilities
LRS	Logistics Readiness Squadron facilities
Mx	Aircraft Maintenance facilities
Dormitory VAQ	Dormitory Visiting Airmen Quarters
Fire Pro	Fire Stations and Water Fire Pump Stations
Sanitation	Sanitary Sewage and Pump Stations
Security	Traffic Checkpoints, Defensive Fighting Positions, and Entry Control facilities
Services	Chapel, Band, Law, Gymnasium, Theater, Mortuary, and Shopping Centers
Water	Water pump stations and water tanks

Analyzed Locations

Base A Locations	BPC/CC - Blatchford Preston Complex/Coalition Compound is used for support functions, supply warehouses and lodging; IA - Used for support functions, warehouses, sanitation, maintenance, operations and admin facilities; LT - Log Town is used for Engineering, Communications, and Logistics squadrons and storage; MSA - Munitions Storage Area; North Gate/East Gate - ECPs NE Ramp - Northeast Ramp and OT - Operations Town house the flying and maintenance squadrons and the airfield.

Base B Locations	ECP 5 - Entry Control Point; LSA is the abandoned area with 4 Air Force Warehouses and concrete pads used for base population surges; Maltese Cross is the staging area for US Apaches; MSA - Munitions Storage Area; The Rock houses base support, community support, and lodging; Quarry houses the flight line and maintenance areas; South Fingers are the south taxiways.

Variance in facility ages (**Age**) and condition (**BCI**) were analyzed for construction standards within each category code and location at the **CAT** and **Location** levels respectively, and across each category code and location at the **base** level. As importance (**MDI**) is primarily based on a facility's category code, variance in **MDI** was analyzed at the **CAT** level and **base** level for **CATs** but not **Location**.

Tables 3.4 - 3.15 show the p-value and groupings using the Tukey correction at a 95% confidence level. For tables related to **Age** and **BCI**, the analysis of variance of individual construction standards at the **base** level (across **CATs** and **Locations)** is presented at the top of the **CAT** and **Location** rows (e.g. Table 3.4 - variance between temporary CE, Security, and Services CATs result in a p-value of 0.336 and only one grouping). Also, the variance between construction standards at the **CAT** and **Location** levels (within particular **CATs** and **Locations)** is presented at the bottom of the **CAT** and **Location** rows under "Permanent, Semi-permanent, and Temporary" (e.g. Table 3.4 – variance between the mean age of Services S facilities and Services T facilities could be similar since Services T could belong to multiple groups). For tables related to **MDI** (i.e. Table 3.8), the variance at the **CAT** level is presented in the "Within CAT Analysis" column; the variance at the **base** level of individual construction standards across categories is presented in the "Base-wide Analysis" column.

3.3.1. Mean Ages for Construction Standards by CAT and Location

3.3.1.1. Base A

Table 3.4 shows that at the **base** level for Base A, as expected, heightened construction standards demonstrate increased differentiation in durations of use based on category code. As shown for example, the null hypothesis is rejected for permanent, and semi-permanent facilities but is accepted for temporary facilities; mean ages are only similar between all category codes for temporary facilities at Base A. Temporary facilities, regardless of category code, are expected to be used for a short amount of time. On the other hand, it is expected that different category codes use semi-permanent and permanent facilities for different durations.

At the **CAT** level, the three construction standards are not exhibiting distinct characteristics with respect to duration of use as evidenced for example by permanent and semi-permanent Airfield facilities whose mean ages are not significantly different. Standards are sharing mean ages in a way expected of a transitioning base. For a base transitioning from expeditionary to enduring, while it is expected that some mean ages for permanent and semi-permanent facilities are similar and some mean ages for semi-permanent and temporary facilities are similar, it is however, expected that the mean ages for permanent and temporary facilities should differ. Interestingly, for CE, Security, and Services category codes, the mean ages between permanent and temporary facilities are not significantly different.

At the **Location** level, there were construction standards that shared similar mean ages (e.g. permanent and semi-permanent facilities within IA, NE Ramp and OT). Unexpectedly, different location types encompassed permanent and temporary facilities whose mean ages were not statistically different (e.g. CC, IA, OT, and North Gate). Not only are temporary facilities being used as long as permanent facilities for CE, Security, and Services category codes, but also throughout particular locations.

At the **base** level, as expected, there is an emphasis on differentiating durations of use for particular construction standards at different **Locations** because all three construction standards had different mean ages in different Locations. For example, the mean ages for permanent facilities at North Gate permanent facilities at West MSA are significantly different.

Evidence from Table 3.4 suggests that Base A's mean facility ages follow the trend expected of a transitioning base to an extent; at the **CAT** and **Location** levels, sets of permanent and semi-permanent facilities and sets of semi-permanent and temporary facilities share similar mean ages.

Table 3.4. ANOVA results for Age and Permanent, Semi-permanent, and Temporary facilities at Base A's CAT, Location, and Base Levels

		Permanent			Semi-permanent			Temporary
Age	CAT[1]	p = 0			p = 0.001			p = 0.336
		A	AB	B	A	AB	B	
		CE	Airfield LRS Security Services	Fire Pro Sanitation	Services	Airfield CE LRS Security	Sanitation	CE Security Services

		Permanent, Semi-permanent, and Temporary					
Age	CAT[1]	p = 0					
		A	Could belong to multiple groups				E
		Services S	Airfield P Airfield S CE P CE S	CE T LRS P LRS S	Sanitation S Security P Security T	Services P Services T	Sanitation P
		Could belong to A					Could belong to E
		Security S					Fire Pro P

		Permanent			Semi-permanent			Temporary	
Age	Location[2]	p = 0.007			p = 0			p = 0.016	
		A	AB	B	A	AB	B	A	B
		North Gate	BPC CC IA OT East Gate NE Ramp North Ramp	West MSA	CC OT	NE Ramp	IA	North Gate	BPC CC IA OT

		Permanent, Semi-permanent, and Temporary					
Age	Location[2]	p = 0					
		A	Could belong to multiple groups				H
		CC S	BPC P BPC T CC T East Gate P	IA P IA S IA T	North Gate P North Gate T North Ramp P	NE Ramp P NE Ramp S OT P OT T	West MSA
		Could belong to A					Could belong to H
		OT S					CC P

[1]CATs: Category Code P/S/T (Permanent, Semi-permanent, Temporary); CE – Civil Engineering; LRS – Logistics Readiness Squadron
[2]Locations: Location P/S/T (Permanent, Semi-permanent, Temporary); BPC/CC - Blatchford Preston Complex/Coalition Compound is used for support functions, supply warehouses and lodging; East and North Gates – ECPs; IA - Used for support functions, warehouses, sanitation, maintenance, operations and admin facilities; LT - Log Town is used for Engineering, Communications, and Logistics squadrons and storage; MSA - Munitions Storage Area; NE Ramp - Northeast Ramp; and OT - Operations Town house the flying and maintenance squadrons and the airfield

3.3.1.2. Base B

Table 3.5 shows that at Base B, similarly to Base A, as construction standards become more permanent, more emphasis is placed on differentiating durations of use at the

base level. At the **CAT** level, while similarly to Base A there is evidence that suggests a blending between permanent and semi-permanent characteristics and between semi-permanent and temporary characteristics, unlike at Base A, there are pairs of construction standards whose mean ages are significantly different (e.g. mean ages of permanent and semi-permanent Maintenance facilities are significantly different). This suggests that Base B is in transition but may not be as advanced as Base A.

At the **Location** level, mean ages between some construction standards were significantly different at some locations (e.g. permanent and semi-permanent facilities at the Quarry) but were not significantly different at others (e.g. permanent and semi-permanent facilities at MSA).

At the **base** level, for Base B, only permanent facilities had different mean ages in different Locations (e.g. mean ages between permanent facilities at the Quarry and the Rock were significantly different). Interestingly, the mean ages of semi-permanent and temporary facilities were similar for all Locations. This suggests that at the across Base B, permanent facilities, with the exception of the Quarry, semi-permanent and temporary facilities are being used for standard durations and there is an emphasis on differentiating durations of use for permanent facilities only at the Quarry.

With respect to mean ages of different construction standards within and across particular CATs and Locations, evidence suggests that Base B has started transitioning but still very much has construction standards that exhibit distinct characteristics in durations of use.

Table 3.5. ANOVA between Age and Permanent, Semi-permanent, and Temporary facilities at Base B's CAT, Location, and Base Levels

Age — CAT[1]

Permanent			Semi-permanent			Temporary
p = 0			p = 0			p = 0.016
A	AB	B	A	Could belong to A	E	
Mx	Airfield Security	CE EOD Lodging Services	Lodging	Water	Services	Airfield CE Lodging Security Services Water Mx
			Could belong to multiple groups			
			CE	Dorm VAQ EOD	Mx Security	

Permanent, Semi-permanent, and Temporary						
p = 0						
A	Could belong to A	Could belong to multiple groups				
Mx P	Airfield P Security P	Airfield T CE P CE S CE T	Dormitory VAQ S EOD P EOD S	Lodging P Lodging S Lodging T	Mx S Mx T Security S Security T	Services P Services S Services T Water S Water T

Age — Location[2]

Permanent		Semi-permanent			Temporary
p = 0		p = 0.024			p = 0.374
A	B				
Quarry	MSA Rock South Fingers	ECP 5 Maltese Cross	MSA Quarry	Rock South Fingers	ECP 5 Quarry Rock South Fingers

Permanent, Semi-permanent, and Temporary							
p = 0							
A	B	G	Could belong to multiple groups				
Quarry P	Rock P	Rock S	ECP 5 S ECP 5 T	MSA P MSA S	Maltese Cross S	Quarry S Quarry T	South Fingers P South Fingers S
Could belong to I		I					
South Fingers T		Rock T					

[1]CATs: Category Code P/S/T (Permanent, Semi-permanent, Temporary); CE – Civil Engineering; EOD – Explosive Ordnance Disposal; Mx– Maintenance, Dormitory VAQ – Visiting Airmen Quarters

[2]Locations: Location P/S/T (Permanent, Semi-permanent, Temporary); ECP 5 - Entry Control Point; LSA is the abandoned area with 4 Warehouses and concrete pads used for base population surges; Maltese Cross - staging area for US Apaches; MSA - Munitions Storage Area; The Rock houses base support, community support, and lodging; Quarry houses the flight line and maintenance areas; South Fingers are the south taxiways.

3.3.2. Mean Building Condition Indexes for Construction Standards by CAT and Location

Fundamentally, at the **base** level, category codes differ in importance levels and locations vary among the base in composition of category codes (i.e. at Base B, the Rock has lodging and support category codes but not Airfield). Therefore, it is expected for mean facility conditions of like construction standards to be significantly different across different **CATs** and **Locations** and to related across similar **CATs** or **Locations**.

At the **CAT** and **Location** levels, mean conditions of different construction standards are expected to be significantly different within a **CAT** or **Location**. However, for a base transitioning from expeditionary to enduring, it is expected that within individual category codes, all facilities are maintained at similar condition levels regardless of construction standard. At transitioning bases, there should still be a select set of temporary facilities that do not share condition levels with semi-permanent and permanent facilities. This select group of temporary facilities is reserved to accommodate surges in base population.

3.3.2.1. Base A

Unexpectedly, as shown in Table 3.6., there were no differences in **mean BCIs a**t the **CAT**, **Location** or **base** levels. While this finding supports the expectation that similar category codes (e.g. base support CATs: CE, LRS, Security, and Services) share similar mean conditions, the trend is not completely followed because the Airfield CAT, which is a primary mission CAT, not a base support CAT, also shares a similar mean BCI. Evidence suggests that at Base A's **CAT**, **Location**, and **base** levels, all facilities are maintained, for the most part, at the same condition.

Table 3.6. ANOVA between BCI and Permanent, Semi-permanent, and Temporary facilities at Base A's CAT, Location, and Base Levels

		Permanent, Semi-permanent, and Temporary							
BCI	CAT[1]	p = 0.363							
		Airfield P	CE P	LRS P	Fire Pro P	Sanitation P	Security P	Services P	
		Airfield S	CE S	LRS S		Sanitation S	Security S	Services S	
			CE T				Security T	Services T	
		Permanent, Semi-permanent, and Temporary							
	Location[2]	p = 0.095							
		BPC P	CC P	East Gate P	IA P	NE Ramp P	North Gate P	OT P	West MSA P
			CC S		IA S	NE Ramp S	North Gate T	OT S	
			CC T		IA T		North Ramp P	OT T	

[1]CATs: Category Code P/S/T (Permanent, Semi-permanent, Temporary); CE – Civil Engineering; LRS – Logistics Readiness Squadron

[2]Locations: Location P/S/T (Permanent, Semi-permanent, Temporary); BPC/CC - Blatchford Preston Complex/Coalition Compound is used for support functions, supply warehouses and lodging; East and North Gates – ECPs; IA - Used for support functions, warehouses, sanitation, maintenance, operations and admin facilities; LT - Log Town is used for Engineering, Communications, and Logistics squadrons and storage; MSA - Munitions Storage Area; NE Ramp - Northeast Ramp; and OT - Operations Town house the flying and maintenance squadrons and the airfield

3.3.2.2. Base B

At Base B's **base** level across category codes, mean facility conditions were only significantly different for permanent facilities between three different category codes: Explosive Ordnance Disposal (EOD), Lodging, and Maintenance (Mx) as shown in Table 3.7. Differences in category codes and importance levels are expected to drive decisions on maintenance investments; these differences could explain why the means between permanent EOD and Lodging facilities and permanent EOD and Mx facilities are significantly different. Interestingly, mean BCIs for semi-permanent facilities or temporary facilities between all category codes were not significantly different suggesting these facilities are maintained at the same condition levels.

Table 3.7. ANOVA between BCI and Permanent, Semi-permanent, and Temporary facilities at Base B's CAT, Location, and Base Levels

BCI – CAT[1]

Permanent			Semi-permanent			Temporary
p = 0			p = 0.315			p = 0.979
A	AB	B				
EOD	Airfield CE Services Security	Lodging Mx	CE Lodging	Mx Security	Services Water	CE Mx Sanitation Security

Permanent, Semi-permanent, and Temporary							
p = 0.467							
Airfield P	CE P CE S CE T	Dormitory VAQ S EOD P	Lodging P Lodging S	Mx P Mx S Mx T	Sanitation T	Security P Security S Security T	Services P Services S Water S

BCI – Location[2]

Permanent		Semi-permanent			Temporary
p = 0		p = 0.200			p = 0.794
A	B	A	AB	B	
MSA	Rock South Fingers	Quarry Rock	Maltese Cross MSA South Fingers	ECP 5	ECP 5 Rock South Fingers

Permanent, Semi-permanent, and Temporary					
p = 0.008					
A		AB			B
MSA P Quarry S Rock P	Rock S Rock T South Fingers T	ECP 5 T	Maltese Cross S MSA S	South Fingers P South Fingers S	ECP 5 S

[1]CATs: Category Code P/S/T (Permanent, Semi-permanent, Temporary); CE – Civil Engineering; EOD – Explosive Ordnance Disposal; Mx– Maintenance, Dormitory VAQ – Visiting Airmen Quarters
[2]Locations: Location P/S/T (Permanent, Semi-permanent, Temporary); ECP 5 - Entry Control Point; LSA is the abandoned area with 4 Warehouses and concrete pads used for base population surges; Maltese Cross - staging area for US Apaches; MSA - Munitions Storage Area; The Rock houses base support, community support, and lodging; Quarry houses the flight line and maintenance areas; South Fingers are the south taxiways.

At the **Location** level, there are instances where the mean BCIs are not significantly different across multiple construction standards (e.g. permanent and semi-permanent facilities within South Fingers) as shown on Table 3.7. This suggests there are no longer distinct construction standards at specific Locations at Base B and that facilities are beginning to be maintained at similar condition levels.

At the **base** level across locations, while permanent and semi-permanent facilities are maintained at different condition levels depending on **Location**, mean conditions between temporary facilities at three locations are not significant. Entry Control Point 5 (ECP 5), the Rock, and South Fingers are not significantly different.

Evidence shows that all facilities at Base A and all semi-permanent and temporary facilities from Base B are maintained at similar condition levels. From an asset management perspective, this suggests limitations on resources are not hindering facility maintenance; also decisions, based on the sampled data, are not driven by facility priorities, construction standards, or locations.

3.3.3. Mean Mission Dependency Indexes by CAT

The expectation for mean Mission Dependency Indexes (MDIs) is variance between construction standards at the **base** level (i.e. category X permanent facilities should have a different importance than category Y permanent facilities). Also, at the **CAT** level, different construction standards can potentially have different MDIs; however, since importance is typically determined by a facility's function (CAT), within a CAT mean MDIs may be similar between construction standards.

3.3.3.1. Base A

As shown in Table 3.8, at the **CAT** level, there is clear evidence of the expected trend that mean importance levels are significantly different between construction standards within some category codes (e.g. Sanitation, Security, and Services) but for others, mean importance levels are not significantly different (e.g. Airfield, CE and LRS). As with Age and BCI, having similar mean MDIs between construction standards is an indication of transition. This is because facilities that share similar MDIs may receive maintenance in the same ways; also construction standards distinctions are applied less religiously the more different facilities are treated the same. It is interesting that for Base A, at the **CAT** level, different types of category codes (e.g. primary mission versus community support) differ in how much they appear to have transitioned. For example, Airfield, which is a primary mission category code, exhibits signs of transition because mean MDIs and mean ages are similar. On the other hand, support category codes, exhibit signs of transition (i.e. $p > 0.05$ for mean MDIs at the **CAT** level for CE) as well as signs of differentiation between construction standards (i.e. $p < 0.05$ for mean MDIs at the **CAT** level for Services). This finding supports the focus in Base A's master plan to transition North East Ramp (NE Ramp) and therefore, Airfield facilities to a more enduring presence and the reason why other category codes are not yet fully transitioned (Base A Master Plan, 2015). Another interesting finding is that mean MDIs are similar between permanent and temporary Security facilities. Upon further investigation, these particular facilities are entry control points (ECPs) and it makes sense that a permanent or temporary structures could satisfy the requirement for this security function. Contrastingly, permanent and temporary Services facilities may or may not share similar importance levels. This is also justified because Services facilities could range from recreation pavilions to gymnasiums to malls and each of these examples, can vary in structure.

At the **base** level, as expected, mean MDIs were significantly different for construction standards across different category codes. These differences show Base A emphasizes prioritization between different category codes; this prioritization likely drives investment decisions because engineers are more informed about risk.

Table 3.8. ANOVA between MDI and Permanent, Semi-permanent, and Temporary facilities at Base A's CAT and Base Levels

CAT[1] Analysis

MDI	Airfield	CE	LRS	Sanitation		Security		Services		
	p = 0.652	p = 0.127	p = 0.187	p = 0.034		p = 0		p = 0.032		
				A	B	A	B	A	AB	B
	P S	P S T	P S	P	S	S	P T	S	P	T

Base-wide Analysis

MDI	Permanent, Semi-permanent, and Temporary									
	p = 0									
	A	Could belong to A	Could belong to multiple groups						Could belong to Y	Y
	Sanitation P	Sanitation S	Airfield P Airfield S	CE P CE S CE T	Fire Pro P	LRS P LRS S	Security P Security S Security T	Services P	Services S	Services T

[1]CATs: Category Code P/S/T (Permanent, Semi-permanent, Temporary); CE – Civil Engineering; LRS – Logistics Readiness Squadron

3.3.3.2. Base B

For Base B at the **CAT** level, the only significant difference in mean importance levels is between semi-permanent and temporary facilities for Lodging as shown in Table 3.9. Like in the civilian sector, lodging or housing requirements can be met through many different types of structures depending on factors such as number of users, expected quality of life, and expected duration of use. Overseas bases accommodate many types of transient personnel; some stay for a couple of weeks while other stay between six months to a year. It makes sense that mean importance levels would vary between semi-permanent and temporary Lodging facilities.

When compared to Base A where half of the category codes share similar mean MDIs, at Base B, all but one category code share similar MDIs. At the **CAT** level, Base A seems to have a greater emphasis on prioritization than Base B but less distinction between construction standards with respect to mean ages and conditions; on the other hand, while most of the category codes at Base B contain construction standards with similar mean

MDIs, there is actually more differentiation between construction standards with respect to mean ages and BCIs. This could mean that having a grasp of the consequence of failure for each facility on a base enables decision makers to transition facilities. Potentially, if one facility is more of a priority to the mission, that particular facility may receive resources and transition before a less important facility. Transition can either be by overlapping characteristics such as age, condition, and importance or identifying those facilities that should be replaced by upgrading to heightened construction standards.

Table 3.9. ANOVA between MDI and Permanent, Semi-permanent, and Temporary facilities at Base B's CAT and Base Levels

<table>
<tr><td rowspan="17">MDI</td><td colspan="6">CAT[1] Level Analysis</td></tr>
<tr><td>Airfield</td><td>CE</td><td>EOD</td><td colspan="3">Lodging</td></tr>
<tr><td rowspan="2">p = 0.583</td><td rowspan="2">p = 0.555</td><td rowspan="2">p = 0.238</td><td colspan="3">p = 0.003</td></tr>
<tr><td>A</td><td>AB</td><td>B</td></tr>
<tr><td>P T</td><td>P S T</td><td>P S</td><td>T</td><td>P</td><td>S</td></tr>
<tr><td colspan="6"></td></tr>
<tr><td colspan="2">Mx</td><td>Security</td><td colspan="2">Services</td><td>Water</td></tr>
<tr><td colspan="2">p = 0.065</td><td>p = 0.125</td><td colspan="2">p = 0.125</td><td>p = 0.534</td></tr>
<tr><td colspan="2">P S T</td><td>P S T</td><td colspan="2">P S T</td><td>S T</td></tr>
<tr><td colspan="6"></td></tr>
<tr><td colspan="6">Base Level Analysis</td></tr>
<tr><td colspan="6">Permanent, Semi-permanent, and Temporary</td></tr>
<tr><td colspan="6">p = 0</td></tr>
<tr><td>A</td><td colspan="4">AB</td><td>B</td></tr>
<tr><td>EOD P
Lodging T
Security T</td><td>Airfield P
Airfield T
CE P
CE S
CE T</td><td>Dormitory VAQ S
Electric S
EOD S
Lodging P
Lodging S</td><td>Mx P
Mx S
Mx T
Security P
Security S</td><td>Services P
Services S
Services T
Water T</td><td>Water S</td></tr>
</table>

[1]CATs: Category Code P/S/T (Permanent, Semi-permanent, Temporary); CE – Civil Engineering; EOD – Explosive Ordnance Disposal; Mx– Maintenance, Dormitory VAQ – Visiting Airmen Quarters

3.3.4. Age, Building Condition Index, and Mission Dependency Index by Originally Intended Age

When focusing on a breakdown of semi-permanent and temporary facilities at the **CAT** and **Location** levels based on the intended ages of 10 and 5 respectively, it is expected that the mean **Ages** and **BCIs**:

- Of semi-permanent facilities within and past 10 years (**S Within** and **S Past**) differ;
- Of **S Past** and temporary facilities past 5 years (**T Past**) differ, with some exceptions;
- And of **S Within** and **T Past**, for the most part, to be similar but could potentially differ.

3.3.4.1. Base A

At the **CAT** level for Base A, the expected trends for mean ages based on originally intended ages were supported as shown on Table 3.10. A surprising finding was that while the mean ages for semi-permanent and temporary facilities past their originally intended ages (**S Past** and **T Past)** differed within both Civil Engineering and Services category codes, the mean ages between **S Past** and **T Past** were similar for Security. Interestingly, the mean Mission Dependency Indexes for **S Past** and **T Past** were similar for CE, Security, and Services. The expectation of all construction standards with similar mean MDIs is for mean ages to be similar, regardless of originally intended age. However, mean MDIs are not expected to be similar across all construction standards or ages. Temporary Security facilities at Base A seem to be used as long as semi-permanent Security facilities but temporary CE and Services facilities are not. This raises the question of whether the mean MDIs between **S Past** and **T Past** for categories CE and Services really are similar as indicated by the results and sample data.

Table 3.10. ANOVA between Age and Semi-permanent and Temporary facilities within and past their originally intended ages at Base A's CAT, Location and Base Levels

Age	CAT[1]	Semi-permanent Past Intended Age	p = 0.015	A	Services
				AB	Airfield Security LRS
				B	CE Sanitation
		Semi-permanent Within Intended Age	p = 0.004	A	CE
				AB	Services
				B	Sanitation
		Temporary Past Intended Age	p = 0.001	A	Security
				B	CE Services
		Semi-permanent and Temporary	p = 0	A	Services S Past
				AC	Security S Past
				Could belong to multiple groups	Airfield S Past CE S Past CE S Within CE T Past LRS S Past Sanitation S Past Security T Past Services S Within Services T Past
				K	Sanitation S Within
	Location[2]	Semi-permanent Past Intended Age	p = 0	A	CC OT
				B	IA
		Semi-permanent Within Intended Age	p = 0.448		CC IA OT
		Temporary Past Intended Age	p = 0.151		IA North Gate OT
		Semi-permanent and Temporary	p = 0	A	CC S Past
				AB	North Gate T Past OT S Past
				Could belong to multiple groups	BPC T Past CC T Past IA S Past IA T Past OT S Within OT T Past
				DE	IA S Within
				E	CC S Within

[1]CATs: Category Code P/S/T (Permanent, Semi-permanent, Temporary) Past/Within (Past or Within Originally Intended Age); CE – Civil Engineering; LRS – Logistics Readiness Squadron
[2]Locations: Location P/S/T (Permanent, Semi-permanent, Temporary) Past/Within (Past or Within Originally Intended Age); BPC/CC - Blatchford Preston Complex/Coalition Compound is used for support functions, supply warehouses and lodging North Gate – ECPs; IA - Used for support functions, warehouses, sanitation, maintenance, operations and admin facilities; LT - Log Town is used for Engineering, Communications, and Logistics squadrons and storage; MSA - Munitions Storage Area; NE Ramp - Northeast Ramp; and OT - Operations Town house the flying and maintenance squadrons and the airfield

Unexpectedly, at the **base** level across all **CATs** and **Locations**, there were no differences in mean BCIs between **S Within, S Past,** and **T Past** as shown on Table 3.11. It is expected that facilities past their intended age would be in poorer condition than those within their intended age. Also, fundamentally, different category codes and different locations are expected to have different mean conditions. However, semi-permanent and temporary facilities at Base A did not follow these trends.

Table 3.11. ANOVA between BCI and Semi-permanent and Temporary facilities within and past their originally intended ages at Base A's CAT, Location, and Base Levels

		Semi-permanent and Temporary					
BCI	CAT[1]	p = 0.363					
		CE S Within	CE T Past	Sanitation S Within	Security S Past	Services S Within	Services T Past
		CE S Past	LRS S Past	Sanitation S Past	Security T Past	Services S Past	
	Location[2]	**Semi-permanent and Temporary**					
		p = 0.303					
		CC S Within	CC T Past	IA S Within	North Gate T Past	OT S Within	OT T Past
		CC S Past		IA S Past		OT S Past	
				IA T Past			

[1]CATs: Category Code P/S/T (Permanent, Semi-permanent, Temporary) Past/Within (Past or Within Originally Intended Age); CE – Civil Engineering; LRS – Logistics Readiness Squadron
[2]Locations: Location P/S/T (Permanent, Semi-permanent, Temporary) Past/Within (Past or Within Originally Intended Age); North Gate – ECPs; IA - Used for support functions, warehouses, sanitation, maintenance, operations and admin facilities; and OT - Operations Town house the flying and maintenance squadrons and the airfield

With respect to importance (MDI) at the **CAT** level, facilities within their originally intended age are no longer expected, for transitioning bases, to have differing levels of importance than the facilities kept in the portfolio past their originally intended age. As shown in Table 3.12, at the **CAT** level, Civil Engineering (CE) and Services follow the expected trend that, mean MDIs are similar between **S Within** and **T Past**. Unexpectedly, mean MDIs were similar between all other pairwise combinations of **S Within**, **S Past**, and **T Past** for CE and Services; and mean MDIs were similar between **S Within** and **S Past** for Sanitation. Within Security, mean MDIs between **S Past** and **T Past** were similar. These unexpected findings further indicate that at Base A's **CAT** level, facilities within and past their originally intended ages may be prioritized, maintained, and possibly transitioned in the same way, regardless of construction type.

Table 3.12. ANOVA between MDI and Semi-permanent and Temporary facilities within and past their originally intended ages at Base A's CAT and Base Levels

<table>
<tr><td rowspan="13">MDI</td><th colspan="8">CAT[1] Level Analysis Past Intended Age</th></tr>
<tr><th colspan="2">CE</th><th colspan="2">Sanitation</th><th colspan="2">Security</th><th colspan="2">Services</th></tr>
<tr><td colspan="2" rowspan="2">p = 0.175</td><td colspan="2" rowspan="2">p = 0.388</td><td colspan="2">p = 0.002</td><td colspan="2">p = 0</td></tr>
<tr><td>A</td><td>B</td><td>A</td><td>B</td></tr>
<tr><td colspan="2">S Within
S Past
T Past</td><td colspan="2">S Past
S Within</td><td>S Past</td><td>T Past</td><td>S Past</td><td>S Within
T Past</td></tr>
<tr><td colspan="8"></td></tr>
<tr><th colspan="8">Base Level Analysis Past Intended Age</th></tr>
<tr><th colspan="8">Semi-permanent and Temporary</th></tr>
<tr><td colspan="8">p = 0</td></tr>
<tr><td>A</td><td>Could belong to A</td><td colspan="4">Could belong to multiple groups</td><td>Could belong to E</td><td>E</td></tr>
<tr><td rowspan="2">Sanitation S Past</td><td rowspan="2">Sanitation S Within</td><td>Airfield S Past</td><td>CE S Within</td><td>LRS S Past</td><td>Security T Past</td><td rowspan="2">Services S Within</td><td rowspan="2">Services T Past</td></tr>
<tr><td>CE S Past</td><td>CE T Past</td><td>Security S Past</td><td>Services S Past</td></tr>
</table>

[1]CATs: Category Code P/S/T (Permanent, Semi-permanent, Temporary) Past/Within (Past or Within Originally Intended Age); CE – Civil Engineering; LRS – Logistics Readiness Squadron

3.3.4.2. Base B

At Base B's **CAT** level, the expected trends for mean ages based on intended ages were mostly supported as shown on Table 3.13.

The mean age within the category code Water was 12 years for both **S Past** and **T Past**, thus, Temporary Water facilities at Base B are being used over twice their intended duration, which is even longer than intended for semi-permanent facilities.

Interestingly, within Civil Engineering, Services, and Security category codes, semi-permanent and temporary facilities are exceeding their originally intended life on average by a standard number of years. Both **S Past** and **T Past** CE facilities have mean ages two years past their intended age (12 and 7 respectively). For **S Past** and **T Past** Services facilities, the average ages are 13 and 9 respectively (3 and 4 years past their intended age respectively). For **S Past** and **T Past** Security facilities, the mean ages are both three years past their intended age (13 and 8 respectively).

The expected trend that mean ages are similar between **S Within** and **T Past** was followed at all applicable Locations (i.e. Entry Control Point 5, the Quarry, the Rock, and South Fingers). This indicates that most temporary facilities are not being used for over twice their intended ages and that semi-permanent facilities are at least being used for as long as temporary facilities.

Also at the Quarry, **S Past** and **T Past** facilities are exceeding their intended ages by similar amounts of time (2 and 3 years respectively). This trend can be expected at the Quarry since all facilities are flight line and maintenance related and since the base is transitioning.

A less expected finding is that also at the Quarry, the mean ages between **S Within** and **S Past** are similar. Upon further investigation, a majority of the **S Within** facilities at the Quarry will exceed their intended age after two years, because their mean is 8 years; and a majority of the **S Past** facilities have only exceed their intended age in the past two years because their mean is also 8 years. Lastly, the overall mean of semi-permanent facilities at the Quarry is 8 years, which is expected for a base transitioning temporary and semi-permanent facilities to permanent.

Table 3.13. ANOVA between Age and Semi-permanent and Temporary facilities within and past their originally intended ages at Base B's CAT, Location, and Base Levels

Age – CAT[1]

Semi-permanent Past Intended Age (p = 0.122)		
CE	Lodging	Services
Dormitory VAQ	Mx	Water
EOD	Security	

Semi-permanent Within Intended Age (p = 0.016)		
A	AB	B
Lodging	Mx	CE
Security	Services	
	Water	

Temporary Past Intended Age (p = 0.009)		
A	AB	B
Water	Airfield	Lodging
	CE	
	Mx	
	Security	

Semi-permanent and Temporary (p = 0)							
A	Could belong to A	Could belong to multiple groups				Could belong to M	M
Lodging S Past	Dormitory VAQ S Past	Airfield T Past	Mx S Past	Services S Within	Water S Within	CE S Within	Lodging T Past
Water S Past	EOD S Past	CE S Past	Mx S Within	Services T Past	Water T Past		
	Security S Past	Lodging S Within	Mx T Past	Security S Within			
			Services S Past	Security T Past			

Age – Location[2]

Semi-permanent Past Intended Age (p = 0.023)		
A	AB	B
Rock	Quarry	MSA

Semi-permanent Within Intended Age (p = 0.700)		
ECP 5	Quarry	South Fingers
Maltese Cross	Rock	

Temporary Past Intended Age (p = 0.157)	
ECP 5	Rock
Quarry	South Fingers

Semi-permanent and Temporary (p = 0)							
A	Could belong to A	Could belong to multiple groups				Could belong to E	E
Rock S Past	MSA S Past	ECP 5 S Within	Maltese Cross S Within	Quarry S Past	South Fingers S Within	Quarry S Within	Rock S Within
		ECP 5 T Past		Quarry T Past			Rock T Past
							South Fingers T Past

[1]CATs: Category Code P/S/T (Permanent, Semi-permanent, Temporary) Past/Within (Past or Within Originally Intended Age); CE – Civil Engineering; EOD – Explosive Ordnance Disposal; Mx– Maintenance, Dormitory VAQ – Visiting Airmen Quarters
[2]Locations: Location P/S/T (Permanent, Semi-permanent, Temporary) Past/Within (Past or Within Originally Intended Age); ECP 5 - Entry Control Point; LSA is the abandoned area with 4 Warehouses and concrete pads used for base population surges; Maltese Cross - staging area for US Apaches; MSA - Munitions Storage Area; The Rock houses base support, community support, and lodging; Quarry houses the flight line and maintenance areas; South Fingers are the south taxiways.

As in Base A and as shown on Table 3.14, for Base B at the **base** level there were no differences in mean condition levels (BCIs) between **S Within**, **S Past**, and **T Past** regardless of category code or location. Semi-permanent and temporary facilities at Base B do not follow the expected trend that different category codes and locations are prioritized or maintained at different condition levels. Instead, all facilities at Base B seem to be maintained at the same condition level. This could indicate, at least for the facilities that have BCI values, that there are enough resources to keep the facilities of every CAT and Location, both new and old, in good condition.

Table 3.14. ANOVA between BCI and Semi-permanent and Temporary facilities within and past their originally intended ages at Base B's CAT, Location, and Base Levels

		Semi-permanent and Temporary			
BCI	CAT[1]	p = 0.906			
		Airfield T Past CE S Past Dormitory VAQ S Past	Lodging S Past Mx S Past Mx T Past	Security S Within Security S Past Security T Past	Services S Within Services S Past Water S Past
	Location[2]	**Semi-permanent and Temporary**			
		p = 0.273			
		ECP 5 S Within ECP 5 T Past Maltese Cross S Within	MSA S Past Quarry S Within	Rock S Within Rock S Past Rock T Past	South Fingers S Within South Fingers T Past

[1]CATs: Category Code P/S/T (Permanent, Semi-permanent, Temporary) (Past or Within Originally Intended Age); CE – Civil Engineering; EOD – Explosive Ordnance Disposal; Mx– Maintenance, Dormitory VAQ – Visiting Airmen Quarters
[2]Locations: Location P/S/T (Permanent, Semi-permanent, Temporary) (Past or Within Originally Intended Age); ECP 5 - Entry Control Point; LSA is the abandoned area with 4 Warehouses and concrete pads used for base population surges; Maltese Cross - staging area for US Apaches; MSA - Munitions Storage Area; The Rock houses base support, community support, and lodging; Quarry houses the flight line and maintenance areas; South Fingers are the south taxiways.

As shown on Table 3.15, at Base B, for most PST category codes, mean MDIs are not significantly different between pairwise combinations of **S Within**, **S Past**, and **T Past** facilities.

The most surprising finding among the similarities in mean MDIs is specifically between **S Past** and **T Past**. The similarities explain the reason for the finding from Table

3.13. For Civil Engineering, Services, Security, and Water category codes, similar importance levels explain why either mean ages or years exceeding intended age are similar between the aforementioned construction standards. These ANOVA results support the findings from the Chi-Square tests that MDI and Past Intended Age are independent for both bases.

Table 3.15. ANOVA between MDI and Semi-permanent and Temporary facilities within and past their originally intended ages at Base B's CAT and Base Levels

<table>
<tr><td rowspan="14">MDI</td><td colspan="7">CAT[1] Level Analysis Past Intended Age</td></tr>
<tr><td>CE</td><td colspan="2">Security</td><td colspan="2">Services</td><td colspan="2">Water</td></tr>
<tr><td>p = 0.778</td><td colspan="2">p = 0.275</td><td colspan="2">p = 0.213</td><td colspan="2">p = 0.630</td></tr>
<tr><td>S Past
S Within
T Past</td><td colspan="2">S Past
S Within
T Past</td><td colspan="2">S Past
S Within
T Past</td><td colspan="2">S Past
S Within
T Past</td></tr>
<tr><td colspan="3">Lodging</td><td colspan="4">Mx</td></tr>
<tr><td colspan="3">p = 0.006</td><td colspan="4">p = 0.008</td></tr>
<tr><td>A</td><td>AB</td><td>B</td><td colspan="2">A</td><td colspan="2">B</td></tr>
<tr><td>T Past</td><td>S Within</td><td>S Past</td><td>T Past</td><td>S Within</td><td colspan="2">S Past</td></tr>
<tr><td colspan="7">Base Level Analysis Past Intended Age</td></tr>
<tr><td colspan="7">Semi-permanent and Temporary</td></tr>
<tr><td colspan="7">p = 0.010</td></tr>
<tr><td>Airfield T Past</td><td>CE T Past</td><td>Lodging S Within</td><td>Mx S Within</td><td>Security S Within</td><td>Services S Within</td><td>Water S Within</td></tr>
<tr><td>CE S Within</td><td>Dormitory VAQ S Past</td><td>Lodging S Past</td><td>Mx S Past</td><td>Security S Past</td><td>Services S Past</td><td>Water S Past</td></tr>
<tr><td>CE S Past</td><td>EOD S Past</td><td>Lodging T Past</td><td>Mx T Past</td><td>Security T Past</td><td>Services T Past</td><td>Water T Past</td></tr>
</table>

[1]CATs: Category Code P/S/T (Permanent, Semi-permanent, Temporary) (Past or Within Originally Intended Age); CE – Civil Engineering; EOD – Explosive Ordnance Disposal; Mx– Maintenance, Dormitory VAQ – Visiting Airmen Quarters

4. CONCLUDING THOUGHTS

This study contributes to the body of knowledge on transient workforces, disaster recovery, and military applications of temporary assets by addressing the gap in literature regarding the application of permanent, semi-permanent, and temporary construction standards on US Air Bases. The two case study locations are classified as transitioning from expeditionary to enduring. Bases A and B were analyzed via base characteristic comparisons and hypothesis testing. The results revealed:

- Relationships between variables related to base facility and infrastructure assets. Differences in the nature of these relationships indicate possible differences in how construction standards are applied at each base; potentially requiring construction standard definitions to be reexamined.
- Asset inventory and durations of use concerns for each base as some assets exceed twice their intended ages.
- Indications of the extent each base has transitioned from expeditionary to enduring at the category code and location levels.

4.1. Objective 1: Planning v Execution

The first objective of this study was to determine the extent that established construction standard definitions and variable relationships are applied at military bases. Results show that although permanent, semi-permanent, and temporary facilities have specific intended lifetimes and functions, at Bases A and B, construction standards are applied similarly in terms of age, condition, and prioritization. As expected for a base transitioning to an enduring presence, the distinct characteristics for each construction standard at the category code and location levels are overlapping as existing facilities exceed their originally intended age.

The analysis of variance results show construction standards have different importance levels within 50% and about 33% of the analyzed category codes for Bases A and B respectively. Base A may emphasize differentiating assignments of mission importance more between construction standards since a larger number of category codes at Base A include construction standards with significantly different mean importance levels or Mission Dependency Indexes (MDIs). This emphasis is also supported by the breakdown of base facilities by MDI which shows distinct high, medium and low priorities for assets at Base A, whereas for Base B, a majority of the assets are considered high priority.

Signs of transition were observed at both bases, where multiple construction standards within category codes and within locations shared similar mean ages and condition levels. When compared to Base B, Base A had:

- More category codes and locations where construction standards had similar mean ages and;
- More locations where construction standards had similar mean conditions.

For both bases, within category codes, all construction standards shared similar mean conditions. This indicates that regardless of category code, at both bases, a facility's construction standard does not affect the condition level in which it is maintained. Factors that affect condition level or maintenance decisions were revealed through Chi-Square tests. Chi-Square results indicate that at both bases, maintenance decisions between construction standards within category codes may be driven by facility age and importance. However, the application of these drivers differs between bases as evidenced by the observed contrasting Chi-Square results. At Base A, facility conditions, prioritization, and decision making seems to transcend category codes and locations more than at Base B.

Since Base B has half the amount of facilities as Base A, particular independent variables may be used in unique ways instead of being used consistently throughout the base.

Specific construction standard definitions are being loosely followed at the bases but there does not seem to be any adverse affects. At both bases, results show temporary and semi-permanent facilities, regardless of importance level, are being operated longer than expected but maintained in good condition, which delays the need for upgraded construction standards. The expected life of assets corresponding to specific construction standards may need to be reevaluated in order to accurately reflect actual durations of use.

4.2. Objective 2: Construction Standard Policy

The second study objective was to determine if asset data supports one or both of the Committee of Appropriations' and Department of Defense's contrasting policies on the use of facilities to either support a temporary or enduring presence respectively.

The test results for both bases mostly supported the DoD's 2008 policy to only use temporary facilities as an interim solution and replace quickly with more permanent structures (Report to Congress, 2008). An enduring presence is reflected by the larger amounts of permanent and semi-permanent facilities than temporary facilities at both bases. However, evidence on whether heightened construction standards replaced originally temporary facilities is uncertain. Additional historical transition information on facilities is needed before a claim can be made in full support of the DoD policy.

The Committee of Appropriation's policy, which allowed for permanent structures in support of an enduring presence but stated temporary facilities should be the priority, was only supported to an extent. For both bases, there are signs of a temporary presence as semi-permanent and temporary facilities are being used past their originally intended ages. However, less than 25% are over five years past their originally intended age and of those, regardless of MDI, a majority are in good to excellent condition. Although temporary facilities have a presence on both transitioning bases, their presence is not the priority or “the rule” (H.R. 1268, 2005, 35). By area, the construction standard with the largest presence is permanent at about 77% and semi-permanent at about 63% for Bases A and B, respectively.

It seems permanent, semi-permanent, and temporary facilities and infrastructure at both bases follow multiple guidelines provided by military publications including:

- Operate and maintain facilities for set periods of time based on specific construction standards;
- Avoid the appearance of a permanent presence;
- And with respect to investment decisions, take into consideration the eventual turnover of assets to the host nation.

Intended lifetimes are assigned to facilities based on their function, expediency, and durability. Facilities at both bases are meeting their intended purposes, however, because of adequate maintenance investments, facilities are lasting much longer than originally intended. In some cases, while facilities may be in good condition, the living standards that accompany lower construction standards are not ideal (Interviews with subject matter experts, 2017). Construction standard definitions may be more of a formality and the durations of use for facility and infrastructure assets may be driven by political influences.

From a sustainability perspective, permanent facilities are more efficient to maintain and are better suited for turnover to and long-term usage by the host nation. From a safety perspective, facilities with permanent construction standards are more resistant to the elements and enemy attack. From a morale perspective, permanent facilities provide a better quality of life for occupants. From an asset management perspective, constructing permanent facilities to replace semi-permanent and temporary ones could be more sensible if the benefit gained justifies the cost (construction, operation, and maintenance), the time to construct, and risks including safety and the possibility of an unexpected eviction. Based on the findings of this study, both bases exhibit signs of a transition to an enduring presence but also signs that indicate a temporary nature of occupation.

Given the contributions of this study on the nature of the application of permanent, semi-permanent, and temporary facilities and infrastructure and how assets show signs of transition, the next question is: "From a financial perspective, are 20+ year operation and maintenance investments on temporary and semi-permanent assets, in order to avoid the appearance of permanency, cost effective and responsible?" To better serve personnel living and working on US Air Bases overseas, Host Nations that offer their hospitality, and the taxpayers who enable the construction, operation, and maintenance of base assets, continuous improvements in asset management must be made.

4.3. Recommendations for Future Work

Future research should investigate, while considering local and theater-wide conditions, whether the operations and maintenance investments on temporary facilities for over 20 years at Bases A, B, and other locations are more justified than either constructing permanent facilities at year five, when the temporary facilities reached their originally intended age, or constructing permanent facilities in place of the temporary facilities to begin with at year zero. The presence of the US Military can provide economic stability and security to a region in exchange for strategic locations that help further US and regional allies' interests. Future research should quantify this exchange and help determine whether involved parties are receiving their expected returns on investments.

Other recommendations for future work include conducting non-parametric tests on the categorical data, especially CATs and Location, to further define the relationships between the variables that affect facility assets. Analysis of temporal data can be conducted including equipment upgrades, renovations, and area changes since each base was established. Investments, with regard to construction and maintenance, can also be examined to determine if surges in a particular construction standard, population, or other factors affect investment decisions. The utilization of a base with authorization from a Host Nation can be compared to public-private partnerships where a concessionaire operates a facility for a set period of time before eventually turning over the asset to the owner. Also, the conditions and factors that trigger the transition of military assets from temporary to permanent construction standards can be explored. Lastly, research can be done on the optimization of facility and infrastructure construction standard combinations and whether assets at bases should transition but have not.

APPENDIX

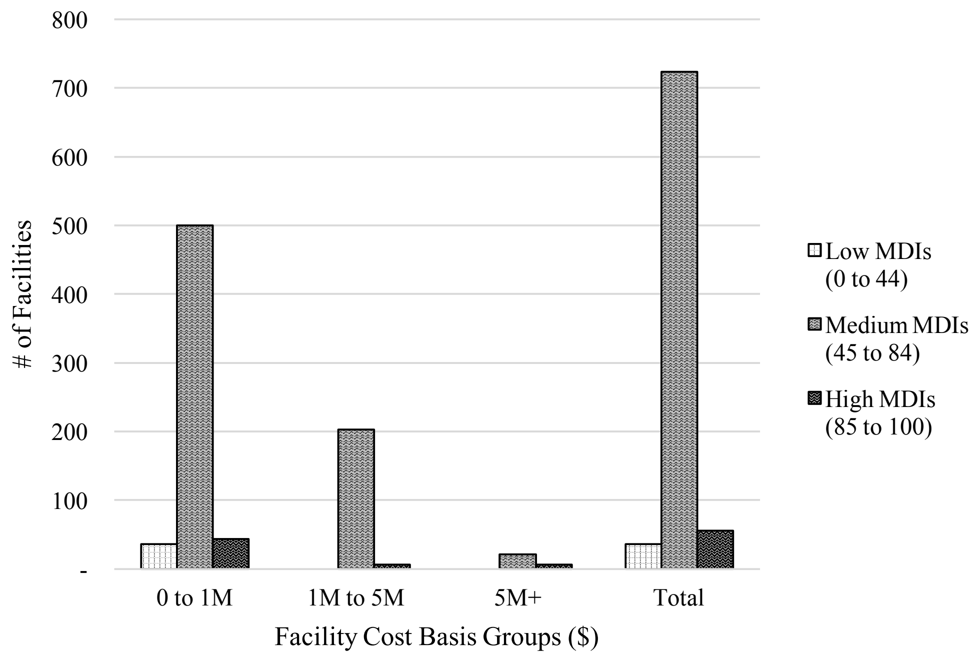


Figure A.1. Base A Mission-based Facility Investment Strategy

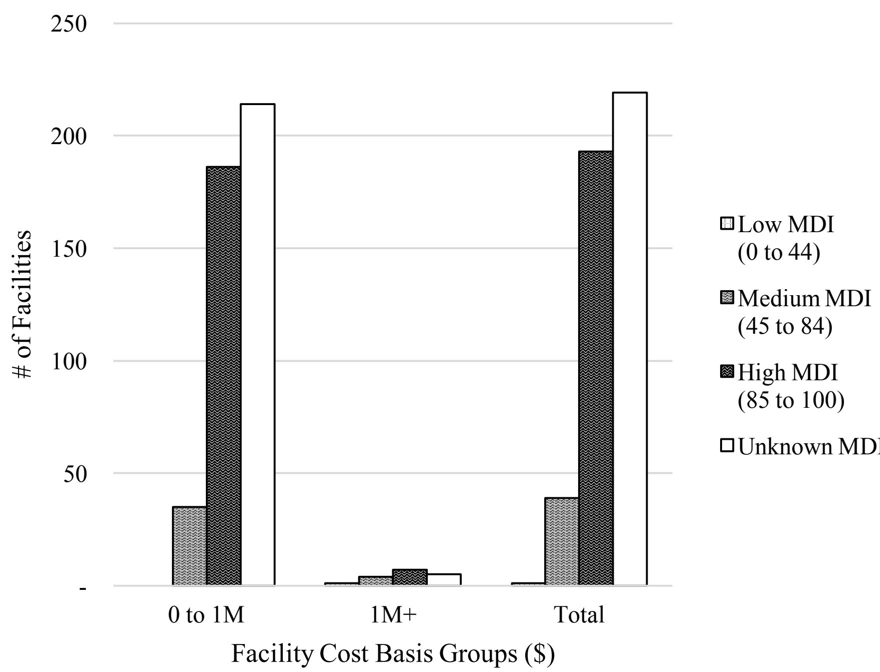


Figure A.2. Base B Mission-based Facility Investment Strategy

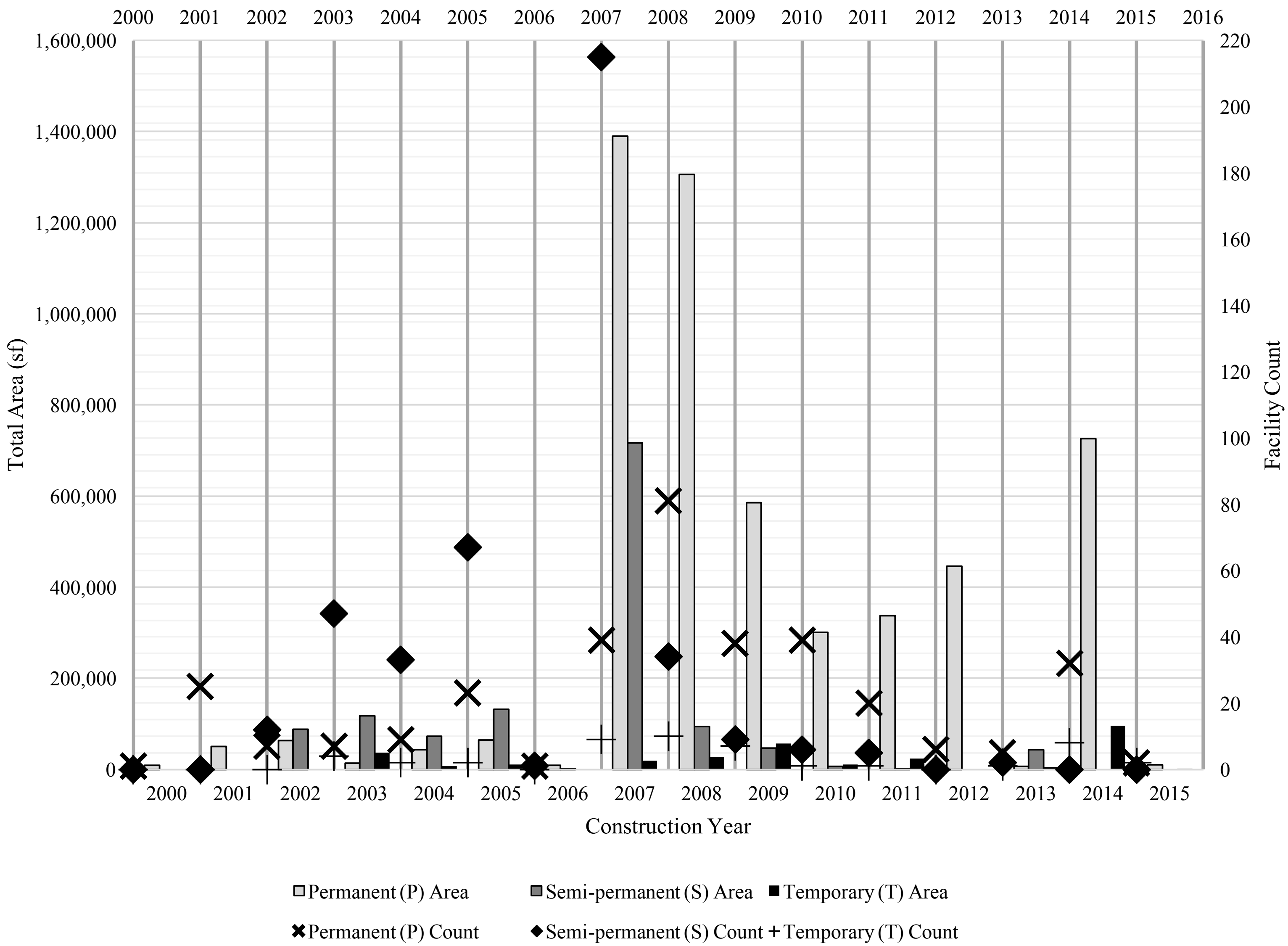


Figure A.3. Base A Yearly Facility Construction Count by Area and Count v Construction Standard

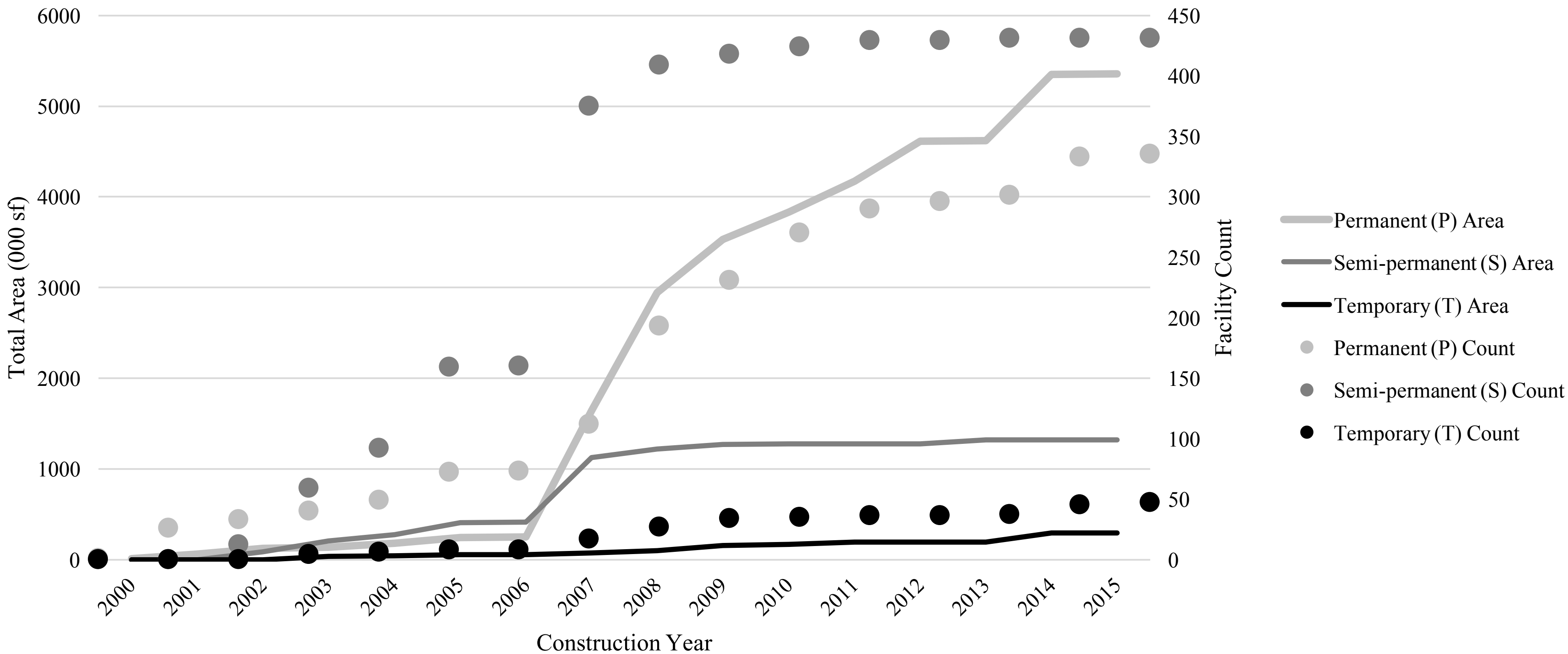


Figure A.4. Base A Total Area and Facility Count v Construction Standard

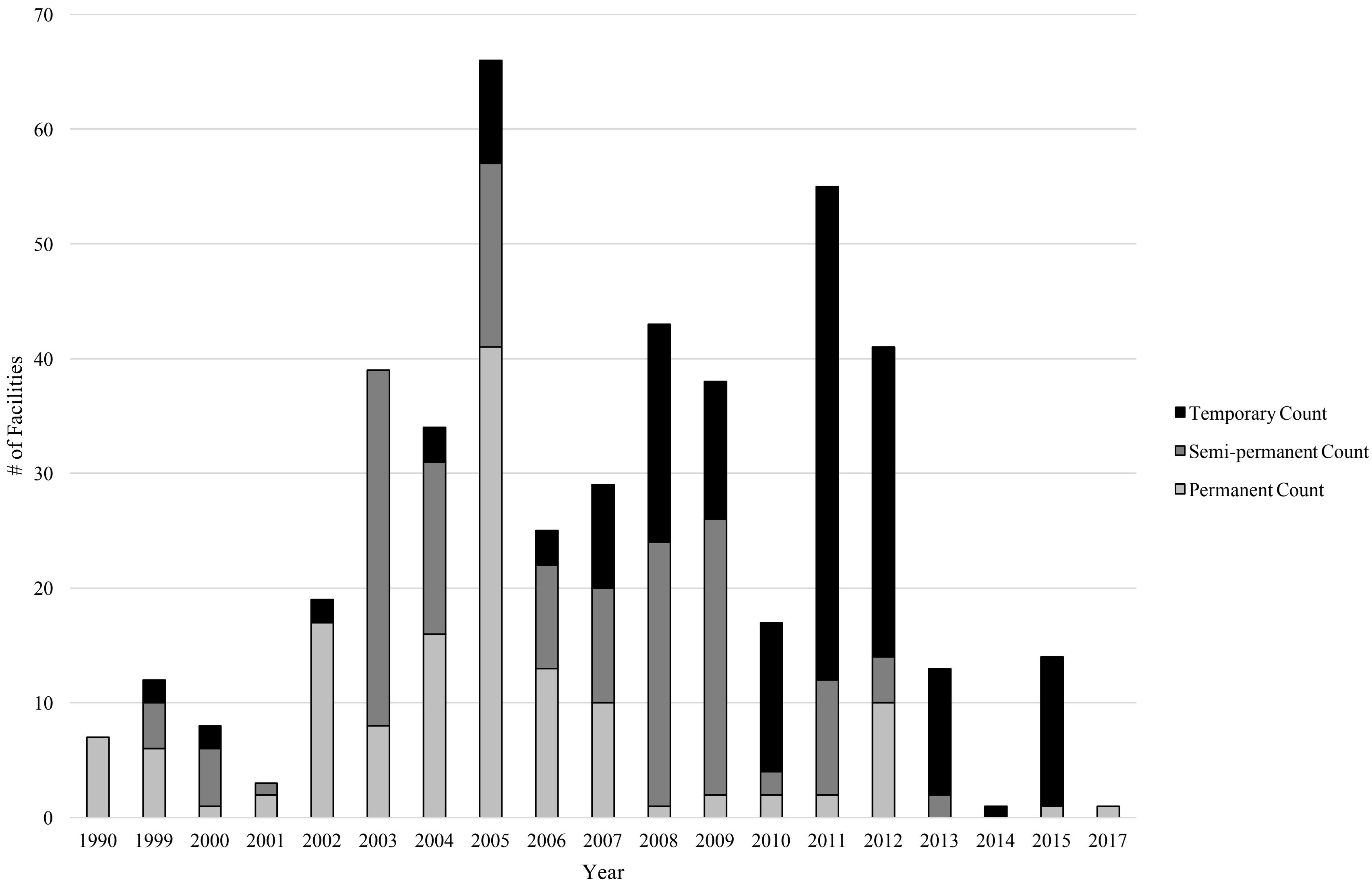


Figure A.5. Base B Facility Count v Construction Type by Year

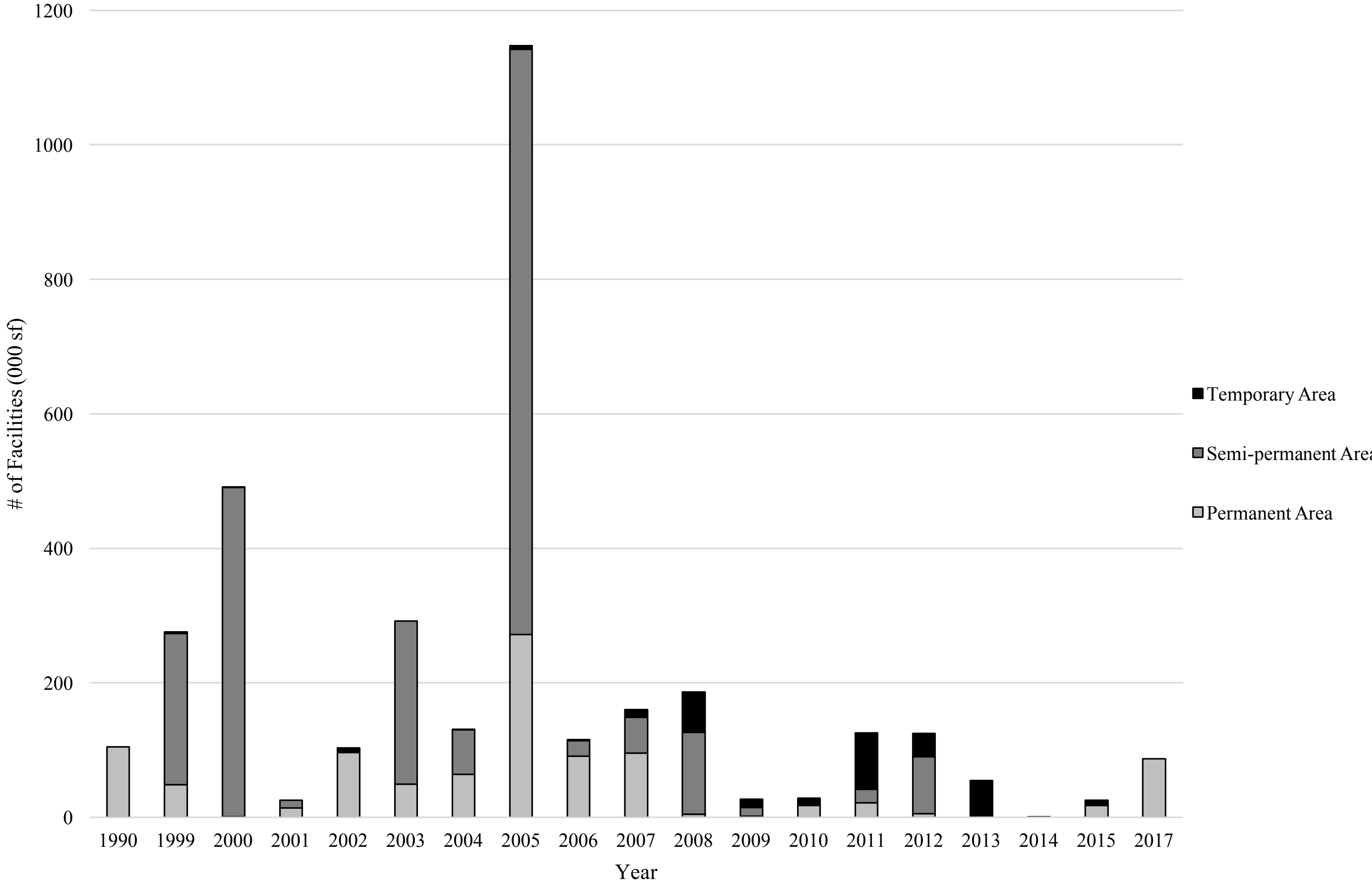


Figure A.6. Base B Facility Area v Construction Type by Year

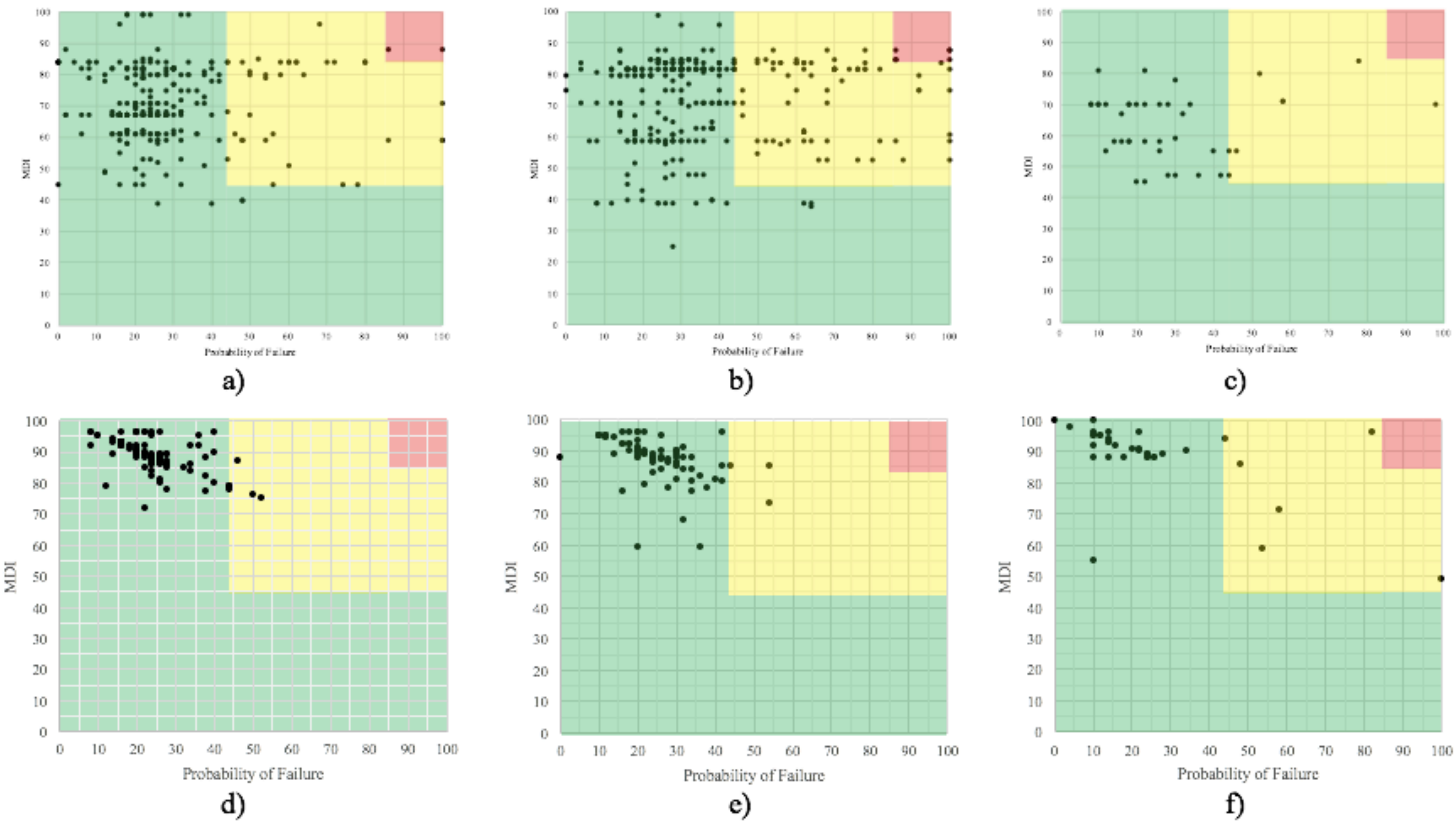


Figure A.7. a-c) Base A Permanent, Semi-permanent, and Temporary Facilities (respectively) MDI v Probability of Failure; d-f) Base B Permanent, Semi-permanent, and Temporary Facilities (respectively) MDI v Probability of Failure

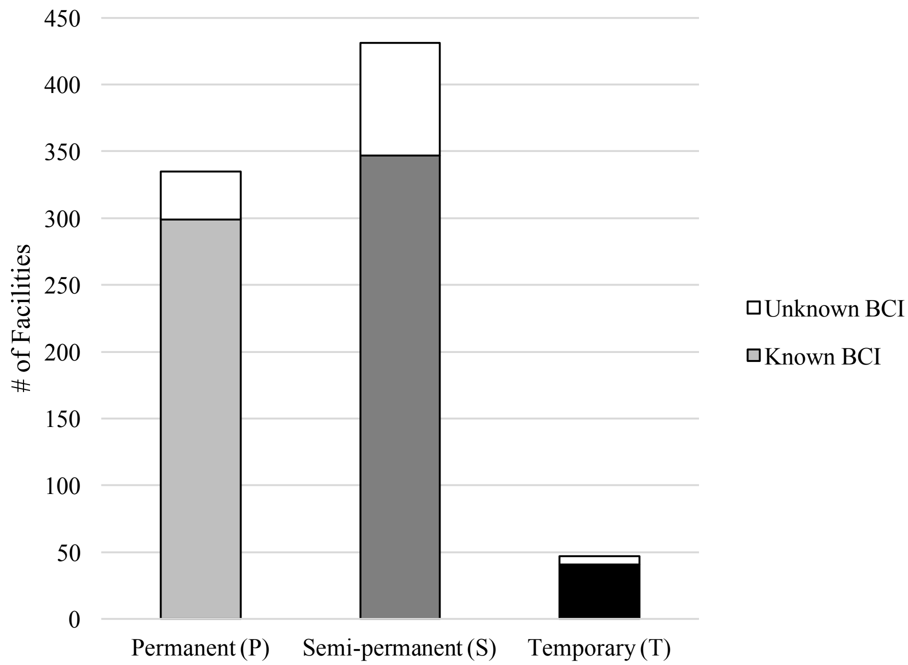


Figure A.8. Base A Building Condition Indexes by Construction Standard

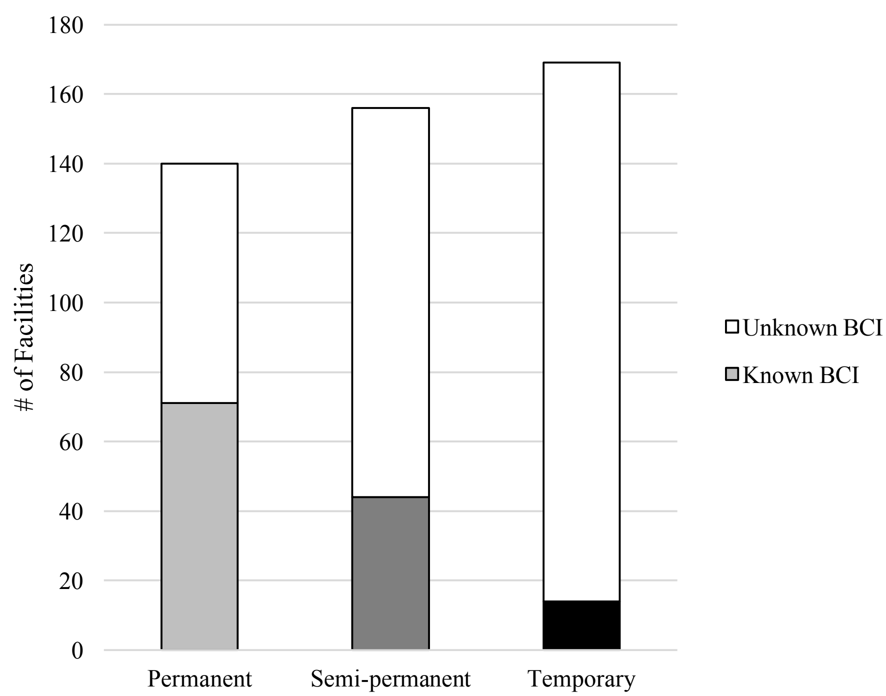


Figure A.9. Base B Building Condition Indexes by Construction Standard

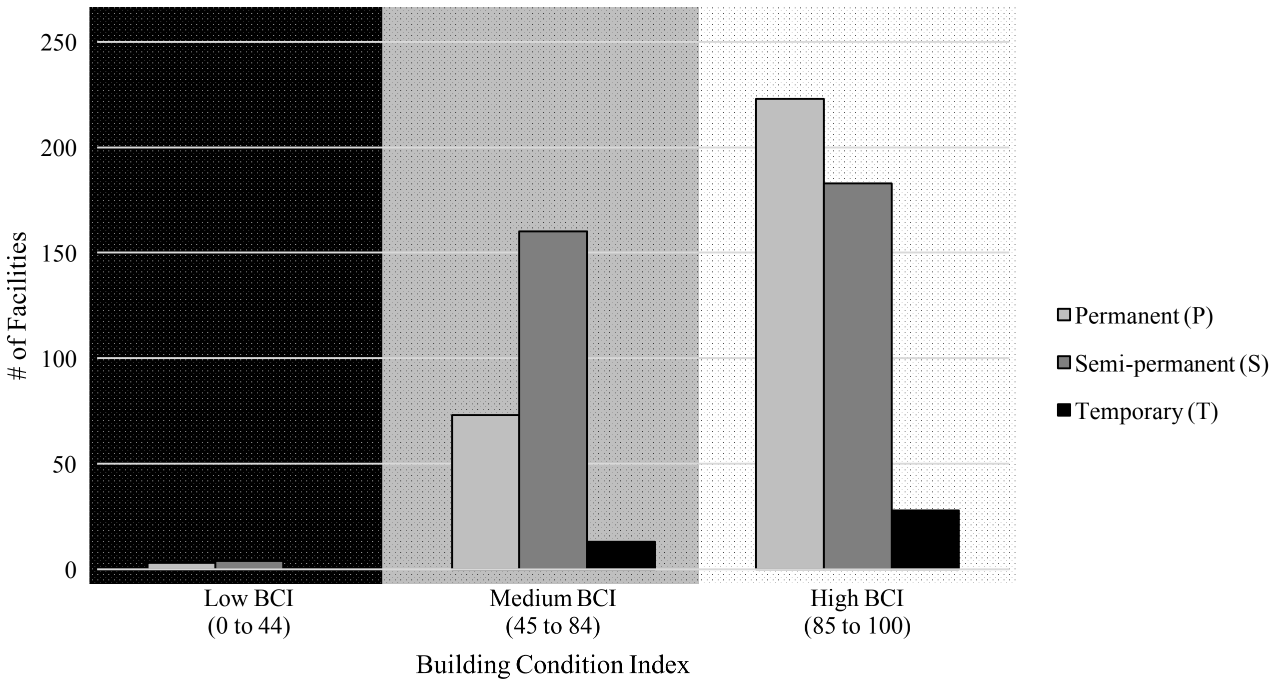


Figure A.10. Base A Known BCI Breakdown (687) by Construction Standard

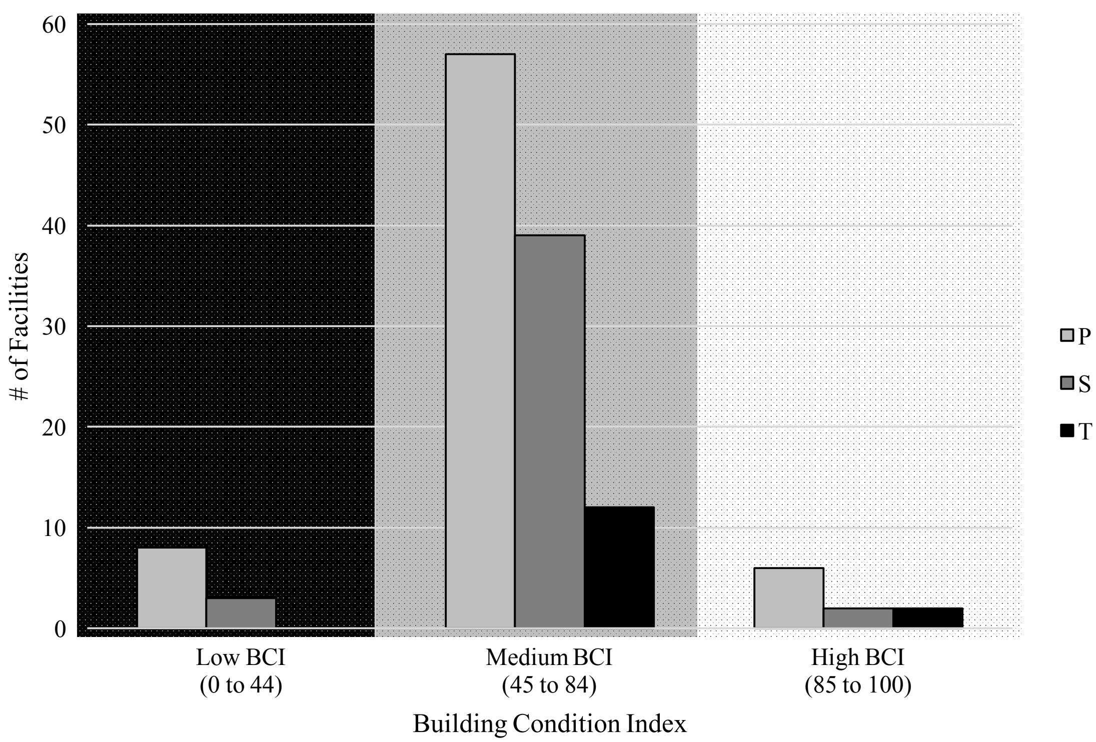


Figure A.11. Base B Known BCI Breakdown (129) by Construction Standard

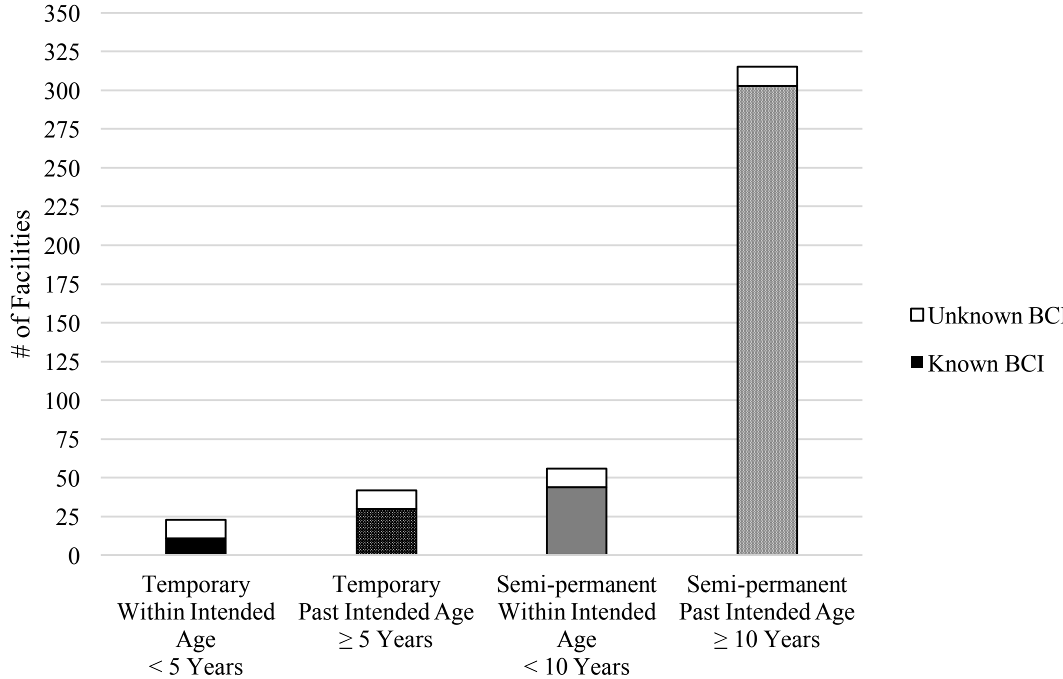


Figure A.12. Base A Semi-permanent and Temporary Building Condition Indexes by Originally Intended Age

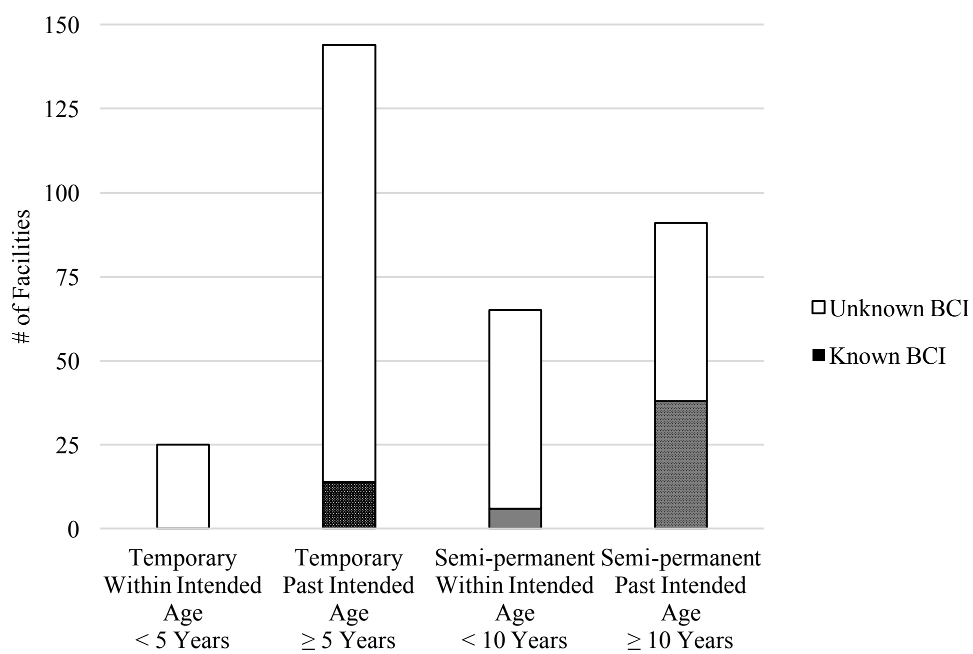


Figure A.13. Base B Semi-permanent and Temporary Building Condition Indexes by Originally Intended Age

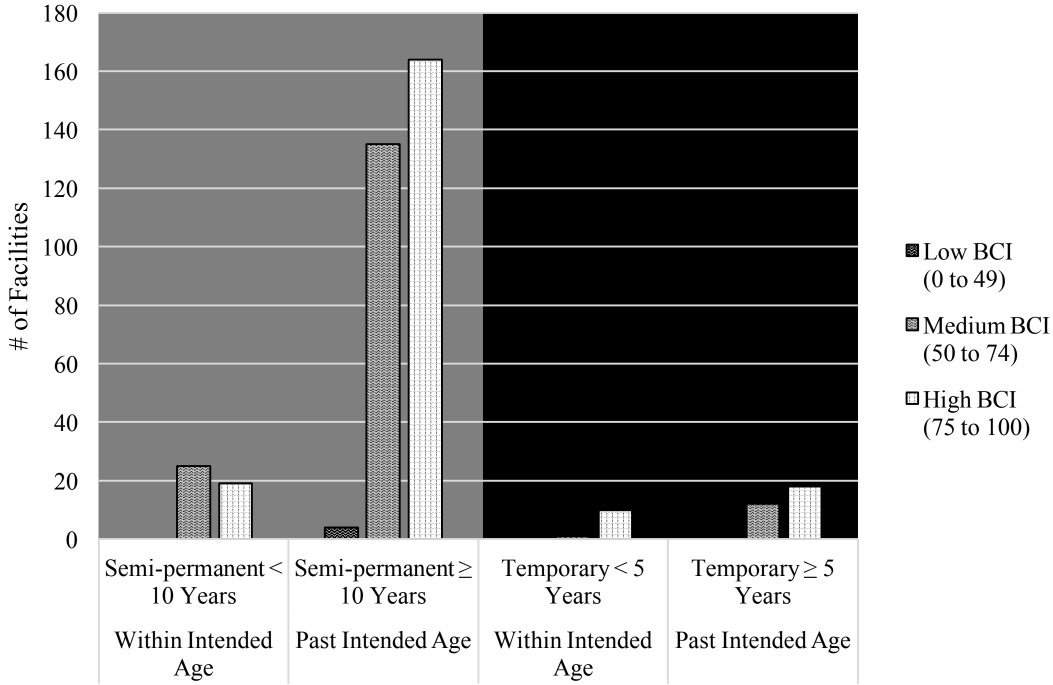


Figure A.14. Base A Known BCI Breakdown by Originally Intended Age v Construction Standard

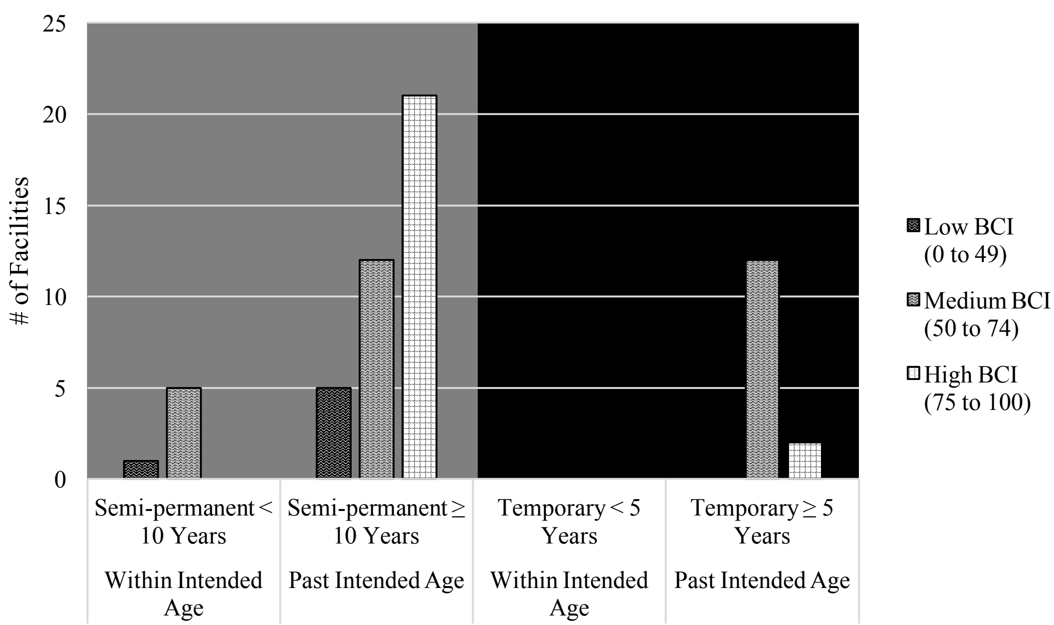


Figure A.15. Base B Known BCI Breakdown by Originally Intended Age v Construction Standard

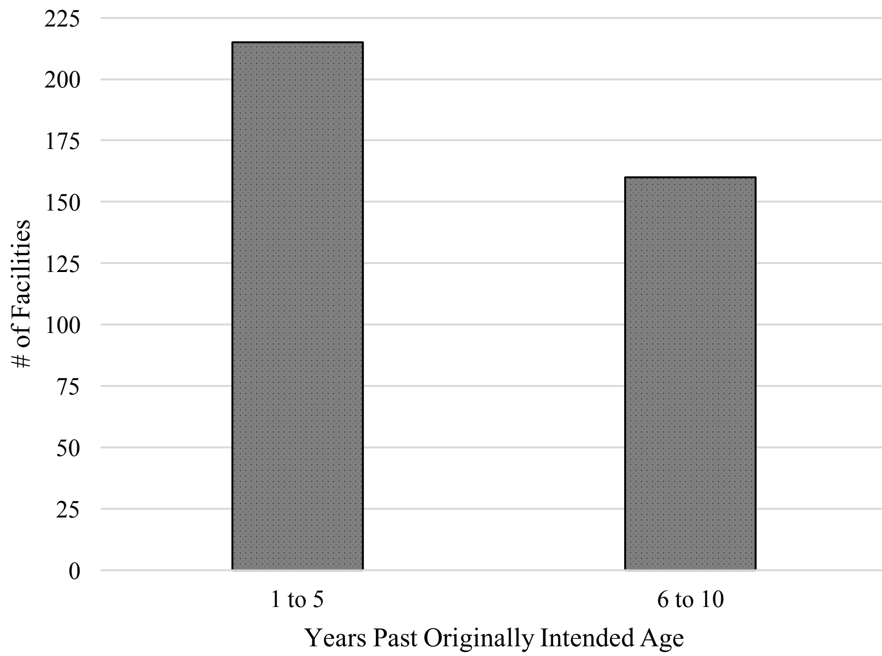


Figure A.16. Base A Age of Semi-Permanent Facilities (375) Past Originally Intended Age (10 Years)

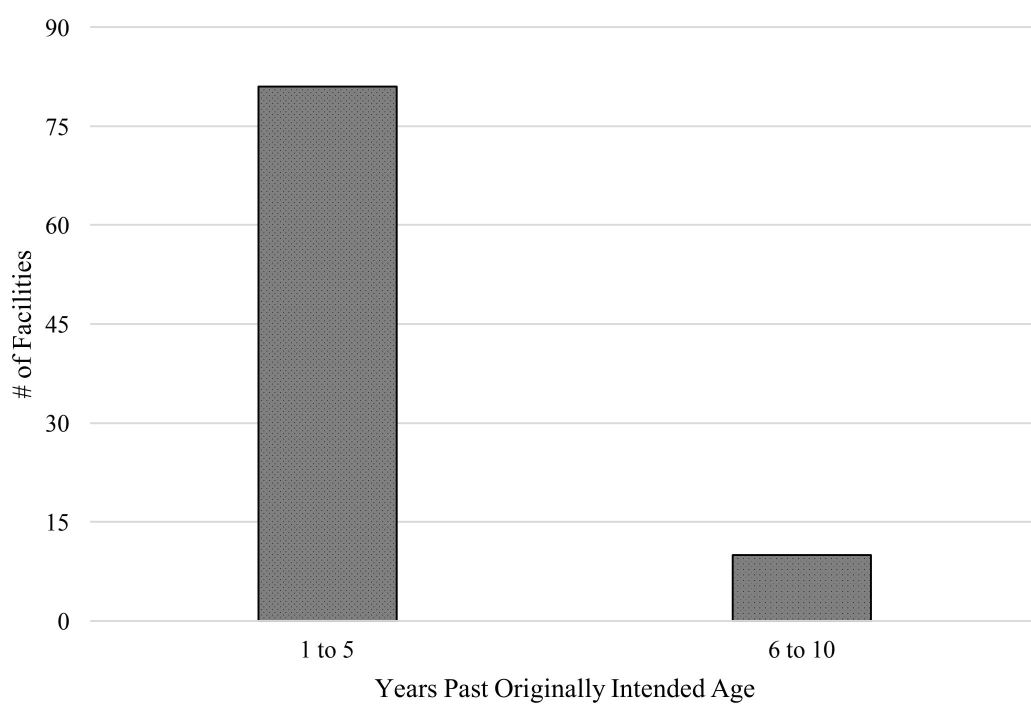


Figure A.17. Base B Age of Semi-Permanent Facilities (91) Past Originally Intended Age (10 Years)

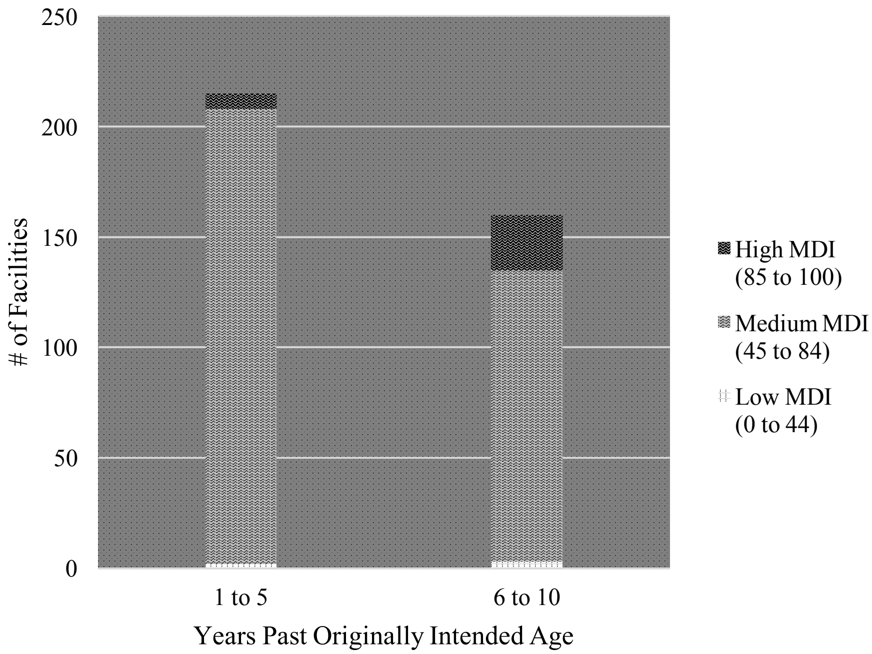


Figure A.18. Base A Age of Known Semi-permanent Facilities (75) Past Originally Intended Age (10 Years) by Mission Dependency Index

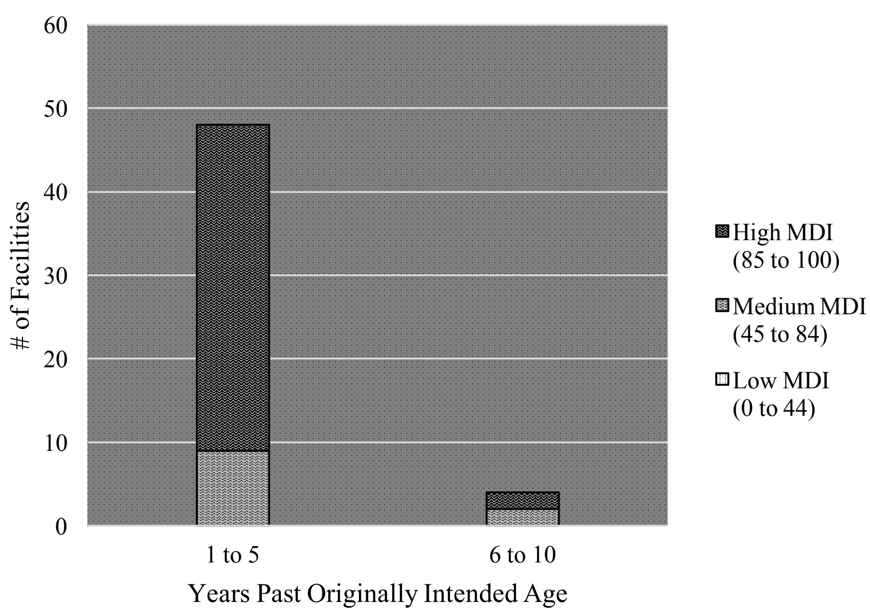


Figure A.19. Base B Age of Known Semi-permanent Facilities (52) Past Originally Intended Age (10 Years) by Mission Dependency Index

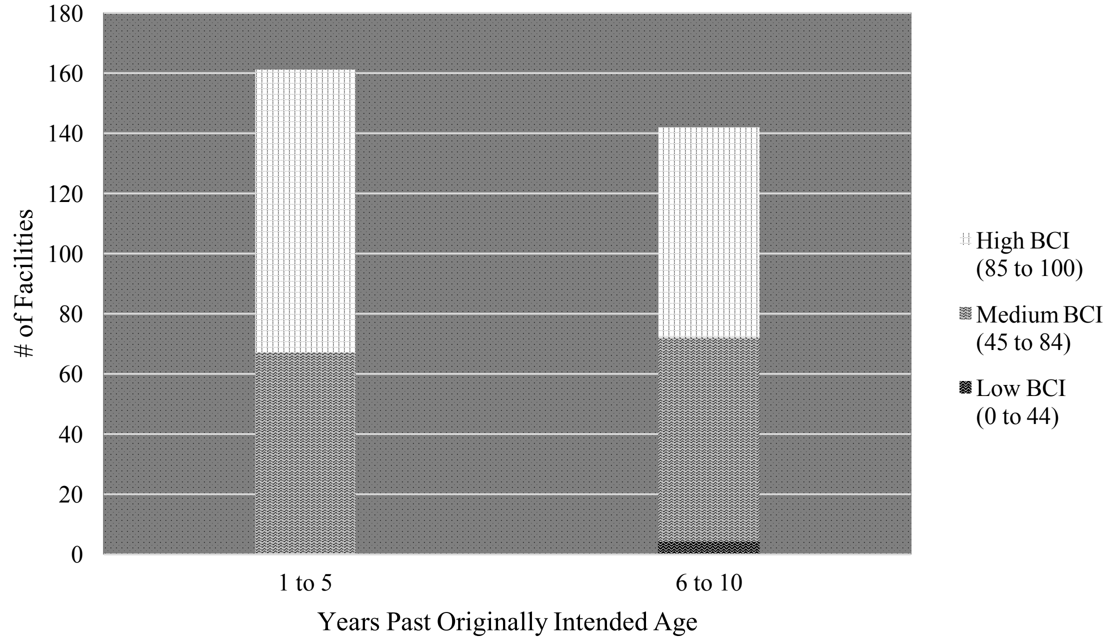


Figure A.20. Base A Age of Known Semi-permanent Facilities (303) Past Originally Intended Age (10 Years) by Building Condition Index

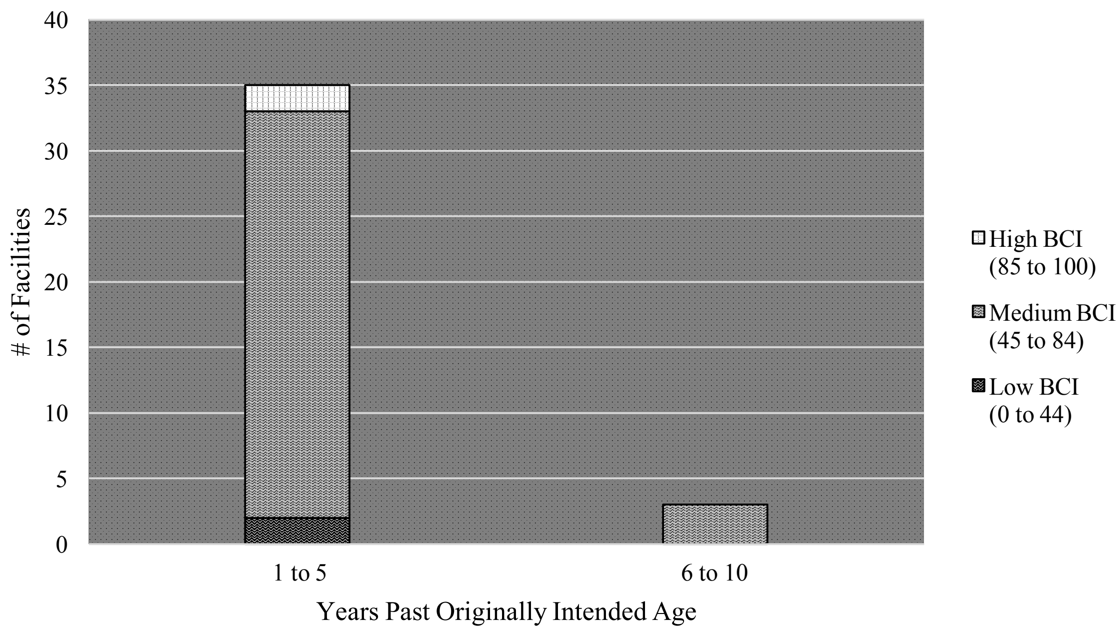


Figure A.21. Base B Age of Known Semi-permanent Facilities (38) Past Originally Intended Age (10 Years) by Building Condition Index

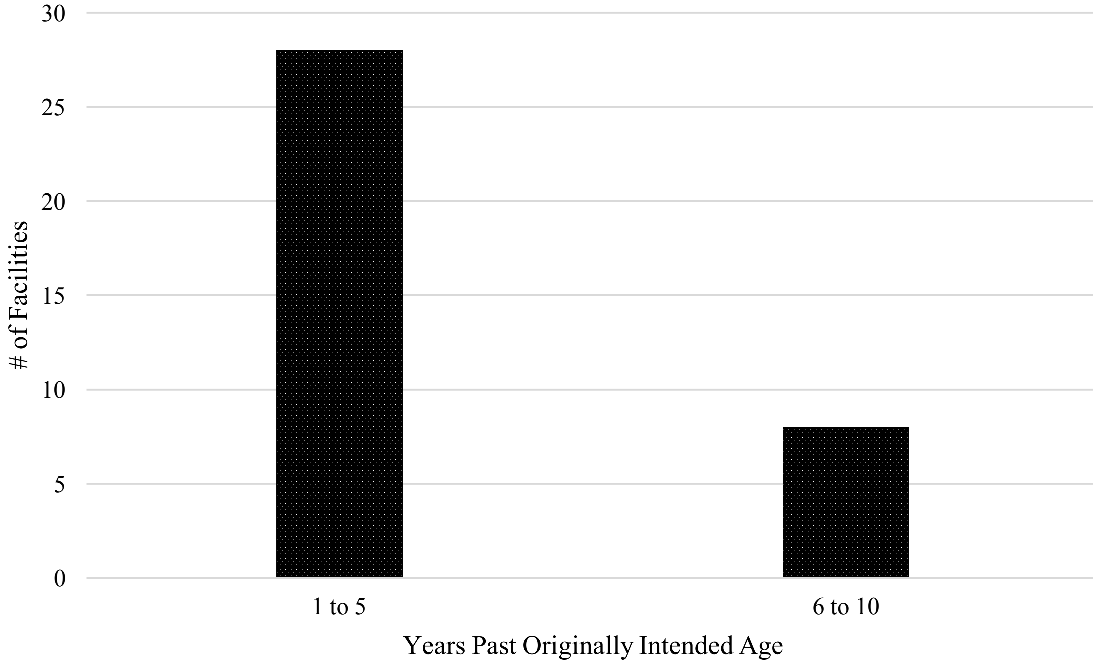


Figure A.22. Base A Age of Temporary Facilities (36) Past Originally Intended Age (5 Years)

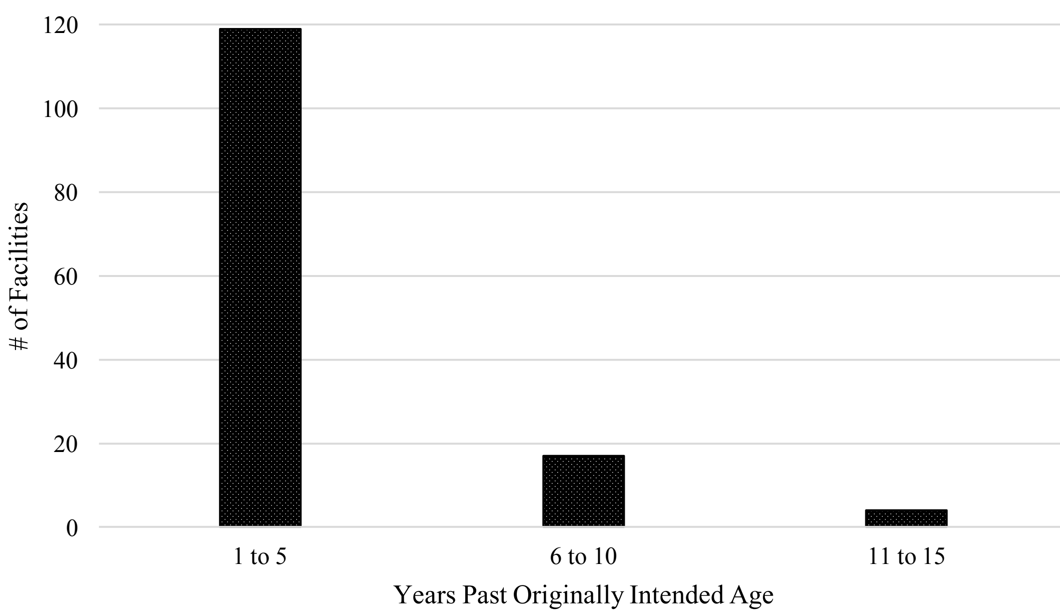


Figure A. 23. Base B Age of Temporary Facilities (144) Past Originally Intended Age (5 Years)

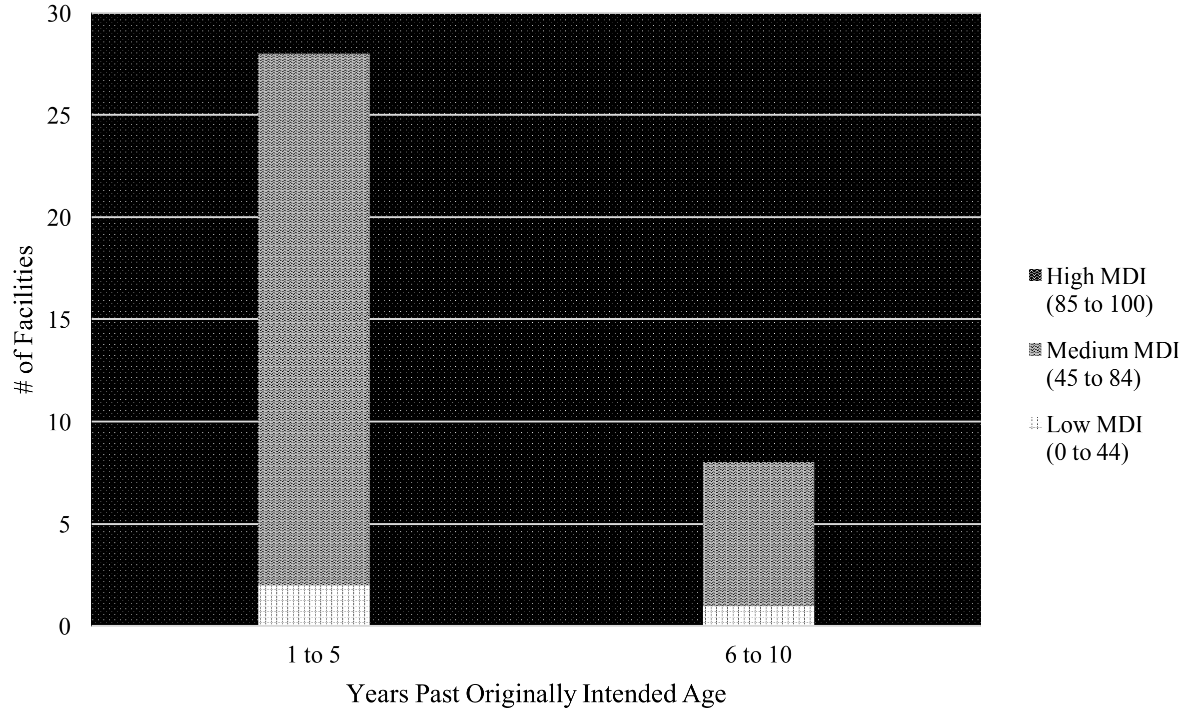


Figure A.24. Base A Age of Known Temporary Facilities (36) Past Originally Intended Age (5 Years) by Mission Dependency Index

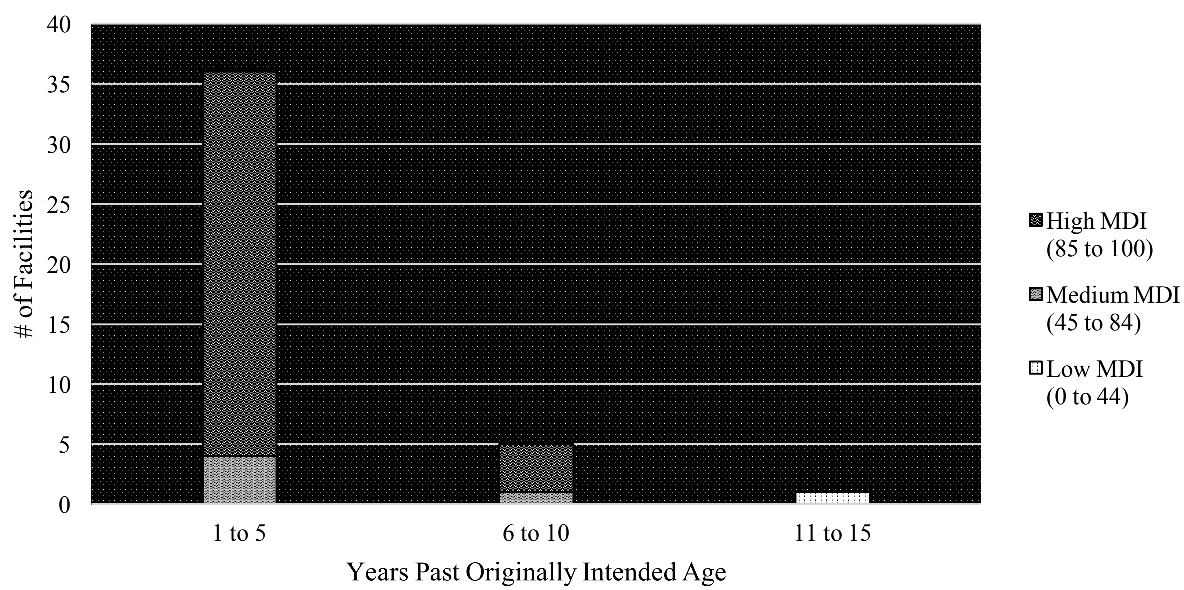


Figure A.25. Base B Age of Known Temporary Facilities (42) Past Originally Intended Age (5 Years) by Mission Dependency Index

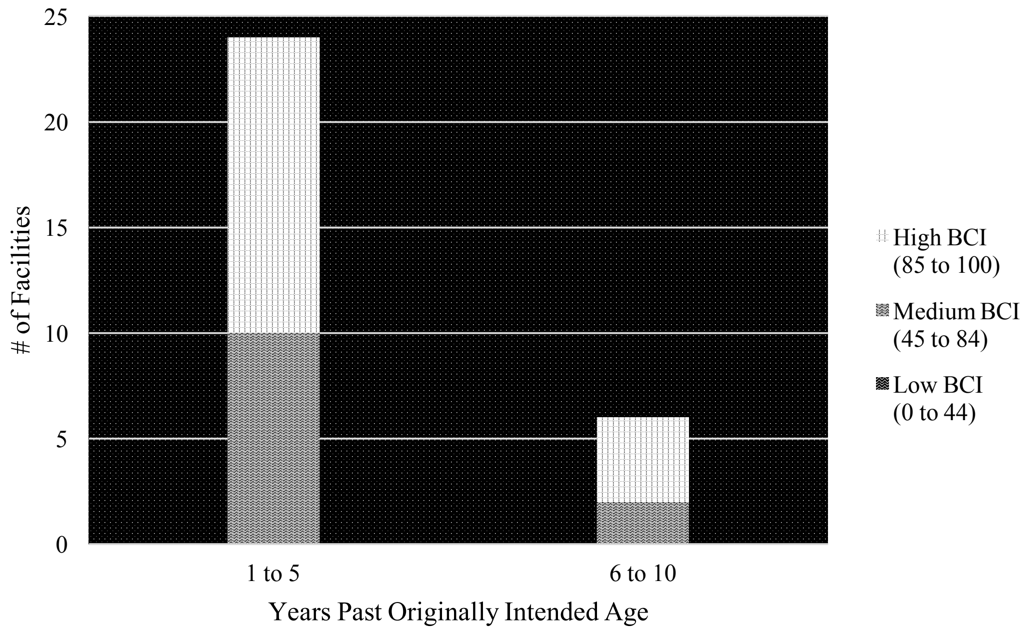


Figure A.26. Base A Age of Known Temporary Facilities (30) Past Originally Intended Age (5 Years) by Building Condition Index

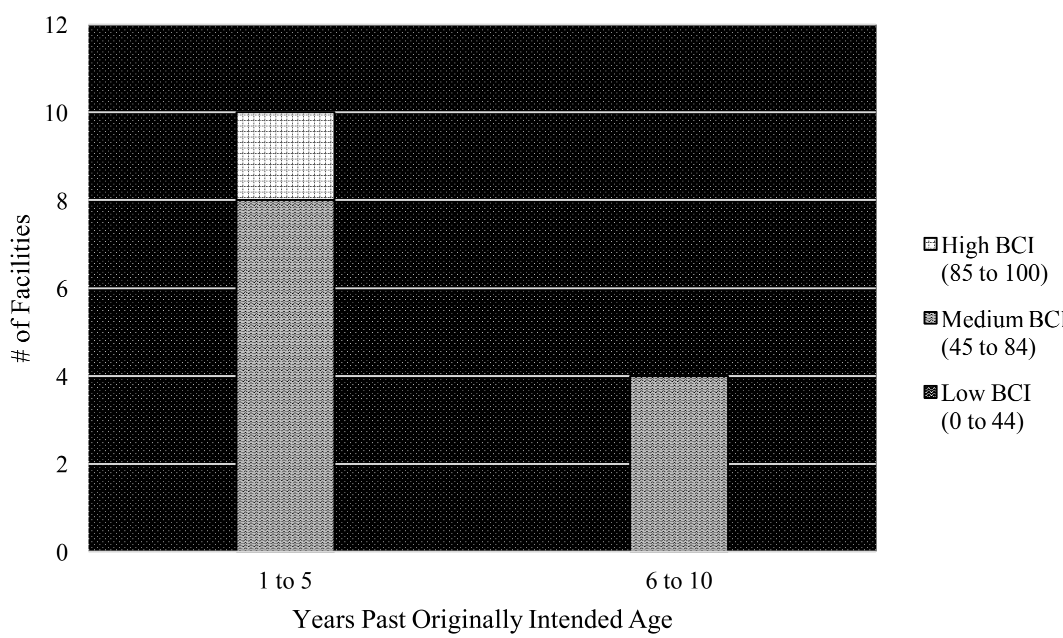


Figure A.27. Base B Age of Known Temporary Facilities (14) Past Originally Intended Age (5 Years) by Building Condition Index

GLOSSARY

Acronyms

BCI	Building Condition Index
CBRN	Chemical, biological, radiological, and nuclear
CCDR	Combatant Commander
CE	Civil Engineering
CERL	Construction Engineering Research Laboratory
EOD	Explosive Ordnance Disposal
ESP	Engineer Support Plan
JFC	Joint Force Commander
LRS	Logistics Readiness Squadron
MDI	Mission Dependency Index
Mx	Maintenance
SecDef	Secretary of Defense
TPFDD	Time-phased Force Deployment Data
USCENTCOM	United States Central Command
USEUCOM	United States European Command
UTC	Unit Type Codes
VAQ	Visiting Airmen Quarters

Definitions

Contingency or Expeditionary	Planned base utilization for less than two years.
Enduring	Planned base utilization for greater than two years.
Engineer Support Plan (ESP)	"The ESP should identify the overall facility requirements and summarize the existing US assets, HN support and multinational assets, and construction needed to satisfy those requirements," (Joint Engineer Operations, 2016, IV-8).
Footprint	All materiel, equipment, and personnel need to support capabilities at the theater, base, and UTC levels (Galway et al., 2002).
Immediate and emergency relief phase or response stage	Debris are cleared, structures are made safe, emergency and temporary shelters are erected and basic transportation, sanitation, communication and power systems are restored (Le Masurier et al., 2006).
Initial	Intended operational duration for up to 6 months.
Non-rotational	A mission with a short duration and no future demand prompting the construction of additional assets (i.e. US Army's temporary fuel pipelines).

Organic	Intended operational duration for 90 days to 6 months.
Permanent	Intended operational duration for more than 10 years.
Recovery or Reconstruction phase	Constructing permanent housing and efforts to return victims to their normal daily lives.
Semi-permanent	Intended operational duration for up to 10 years.
Tail	Functions that support offensive military capabilities
Temporary	Intended operational duration for up to 5 years.
Tooth	Offensive military capabilities
XFBKA	The UTC that includes billeting facilities intended to support a beddown at a bare base, was actually used to accommodate personnel at established bases and refugees in humanitarian operations (Galway et al., 2002).

ANALYZED CATEGORY CODES (CATS)

Airfield	Buildings that directly support the airfield including housing for radar approach control systems, EOD personnel and equipment, sunshades, and Fuel personnel	Bases A and B
Bldg CE	Civil Engineering facilities	Bases A and B
Bldg EOD	Explosive Ordnance Disposal facilities	Bases A and B
Bldg Lodging	Billeting facilities	Bases A and B
Bldg LRS	Logistics Readiness Squadron facilities	Base A
Bldg Mx	Aircraft Maintenance facilities	Bases A and B
Dormitory VAQ	Dormitory Visiting Airmen Quarters	Base B
Fire Pro	Fire Stations and Water Fire Pump Stations	Base A
Sanitation	Sanitary Sewage and Pump Stations	Base A
Security	Traffic Checkpoints, Defensive Fighting Positions, and Entry Control facilities	Bases A and B
Services	Chapel, Band, Law, Gymnasium, Theater, Mortuary, and Shopping Centers	Bases A and B
Water	Water pump stations and water tanks	Base B

VARIABLE DEFINITIONS

Base A Locations	BPC/CC - Blatchford Preston Complex/Coalition Compound is used for support functions, supply warehouses and lodging; IA - Used for support functions, warehouses, sanitation, maintenance, operations and admin facilities; LT - Log Town is used for Engineering, Communications, and Logistics squadrons and storage; MSA - Munitions Storage Area; North Gate/East Gate - ECPs NE Ramp - Northeast Ramp and OT - Operations Town house the flying and maintenance squadrons and the airfield.	Base A
Base B Locations	ECP 5 - Entry Control Point; LSA is the abandoned area with 4 Air Force Warehouses and concrete pads used for base population surges; Maltese Cross is the staging area for US Apaches; MSA - Munitions Storage Area; The Rock houses base support, community support, and lodging; Quarry houses the flight line and maintenance areas; South Fingers are the south taxiways.	Base B
Building Condition Index	The BCI is the overall building condition score based on a roll-up of all section condition scores and weighted by replacement value.	Bases A and B
Building Type	A description of a facility's material make up or structure.	Base B
Category Code	Designator of a facility's scope, requirements, and general function.	Bases A and B
Category Code Definition	Category Code translated into a brief description of the facility's general function or user.	Bases A and B
Const Type	Construction Type: Permanent – P; Semi-permanent – S; Temporary – T	Bases A and B
Cost Basis	The original acquisition, construction, and improvement costs of the facility. Cost Basis includes improvements that exceed the capitalization threshold of $100k if executed before 1 Oct 2006 or $20k if executed on or after 1 Oct 2006.	Bases A and B
Customer	User of the facility	Base B

Description	A brief description of the facility's specific function	Bases A and B
Eff Date	Date the facility completed construction	Base B
Expensed Improvement	Improvement costs that did not exceed the capitalization threshold.	Bases A and B
Fac #	Unique building identifier	Bases A and B
Group	Differentiates Electric Sub Stations, HVAC Plants, and other buildings.	Base A
Imp Date	Date the expensed improvement was executed	Base B
Inst	AEWV is the designator for Base B.	Base B
Mission Dependency Index	The MDI is based on the mission owner's assessment of the importance of each building to the accomplishment of the mission. Each building has an MDI score in the 0-100 range, where 100 is most critical and 0 is least critical.	Bases A and B
Mission P	The priority of a facility's contribution to the base's mission. Generally related to a facility's MDI.	Base B
Mission T	The specific aspect of the base's mission the facility supports. Either Base, Community, Expeditionary, Mission, or Primary Mission.	Base B
Multi Use Facility	Buildings that house multiple Category Codes or Functions	Base B
Name	Facility Name	Base B
Occ Org	Organization that uses the building and that the customer belongs to. Includes the branches of the US Military and Allied Countries.	Base B
Past Intended Usable Age	Yes if a Temporary facility is over 5 years old or a Semi-permanent facility is over 10 years old.	Bases A and B
Permanent age > 10 Years	Calls out permanent facilities that may potentially be in poor condition.	Bases A and B
Possible Transition	When buildings have multiple data row entries, and either the Const Type or Year Comp differ between the row entries.	Base B

Real Property Installed Equipment	The cost of the acquisition and installation of the Real Property Installed Equipment. RPIE are “those items of government-owned or leased accessory equipment, apparatus and fixtures that are essential to the function of the facility” (AFI 32-9005, 2015).	Base B
Source	RP if the row data was taken from the RP List worksheet or TABS if the row data was taken from the A Type, B Type or E Type worksheet.	Base B
Type	ACES Database Codes for a building’s purpose A - Single Purpose Building B - Multipurpose Building E - Facility other than Building	Base B
Year Comp	The year the facility completed construction.	Bases A and B

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