Dive Team Implodes Building on Kwajalein Atoll

By Captain Charles T. Denike

Kwajalein Atoll, the largest coral atoll in the world, is part of the Republic of the Marshall Islands in the western Pacific Ocean. Since 1944, when the United States captured the atoll from the Japanese, it has been used for military purposes. Unaccompanied personnel who are assigned there live in apartment-style housing. When one of these buildings (Building 708) was determined to be unsafe for occupancy, plans were made to implode the building to make way for a new structure.

The project, which was accomplished in July 2006, took place in two phases: an *explosive demolition* conducted by the 7th Engineer Dive Team, 29th Engineer Battalion, and a *mechanical demolition and debris removal* conducted by the 82d Engineer Company (Engineer Support Company [ESC]). The dive team detonated 84 pounds of M1 dynamite, bringing the three-story, 450-foot-long building to the ground. Imploding the building facilitated the mechanical demolition by reducing the height of the structure by at least half and catastrophically damaging the entire structure. A blast of this type had never been performed with military explosives and required extensive research and planning.

Preparation

From March through June, Kwajalein Range Services (KRS) conducted soft demolition of the building, which included removing all glass, interior walls, paint, electrical wires, plumbing, fixtures, and furniture. KRS also installed window barricades on surrounding buildings to protect against glass breakage, but did not remove the building's four stairwells, each of which went to the third floor and was surrounded by secondary columns and concrete masonry unit (CMU) walls. While not designed to be load bearing beyond the limits of the stairwells, these columns and walls were strong enough to withstand a substantial load. With the time allowed, the 82d Engineer Company was able to remove three of the four stairwells on the first floor.

Glass and other interior components were removed from Building 708 in preparation for the implosion.

Demolition

The blast team placed the M1 charges inside the columns surrounding the stairwells. To do so, they drilled boreholes 1.375 inches in diameter and 13 inches deep at elevations of 2 and 6 feet into the north faces of each column to protect the M11 blasting caps from fragmentation. After drilling the boreholes, the blast team and KRS installed a chain-link fence and a nonwoven geotextile fabric curtain around the south, west, and north sides of the first floor.

The blast team conducted a test shot on 6 July to verify the charge quantity and placement. The M1 dynamite completely breached the column at the charge placements. The remaining concrete at an elevation of 4 feet was severely displaced, and the rebar was deformed. The chain-link fence and nonwoven geotextile fabric wrap remained intact. The test shot confirmed the proposed plan, and the blast team loaded the structure with explosives for the blast.

The team primed 168 charges, loaded them in the boreholes, and stemmed the boreholes with expanding foam. They wrapped all 84 columns with two layers of chain-link fence and nonwoven geotextile fabric to contain fragmentation. On each column, the chain-link fence was secured with four hog rings and the nonwoven geotextile fabric was secured with three wire ties. Four M15 high- and low-strength time delay blasting caps (two primary and two secondary systems) were used, and two M11 high-strength blasting caps were used to create the 225 milliseconds delay between each of the eleven sequences that detonated consecutively from the south to the north end of the building. The net explosive weight (NEW) of each sequence was 8.92 pounds and the total NEW for all sequences was 94.45 pounds. Since the sequences were delayed 225 milliseconds (more than the industry standard of 8 milliseconds), the entire blast was modeled with a NEW of 8.92 pounds. The blast was initiated with two M81 igniters (primary and secondary) and two M13 (1,000-foot) low-strength blasting caps.

The blast collapsed the entire first floor, 75 percent of the second floor, and 50 percent of the third floor. The final stairwell that was unable to be removed on the first floor supported some of the structure during the collapse. Portions of the second and third floor remained supported since the stairwells had not been removed above the first floor.

Quantity-Distances

The most significant deviation from normal military explosive procedures was the use of reduced safe distances. The blast team used a distance of 681 feet for the blast (both the test shot and the entire building) and 200 feet for accidental detonations. The quantity-distance was calculated using the equation:

$$D\ (\text{ft}) = K \times W^{1/3}$$

D is the distance in feet, K is a factor (also called K-factor) that is dependent on the permitted risk level, and W is NEW in pounds. For accidental detonations, a K-factor of 40[1] is normally used; however, this distance does not account for fragmentation. Therefore, a distance of 200 feet was used for accidental detonations. For intentional detonations, a K-factor of 328[2] was used, representing an incident overpressure of 0.0655 pounds per square inch at the calculated distance. This resulted in a distance of 681 feet and accounted for the dangers of overpressure. There was no concern of fragmentation because control measures were in place to limit the distance that fragmentation was thrown.

Blast Considerations

Concerns about fragmentation included the distance of flying debris, damage to neighboring buildings, and damage to initiation systems. The fragmentation could have caused window breakage in neighboring buildings and severed the sequences. Fragmentation was mitigated using three methods:

- Using protective materials at the charge placement. Each column was wrapped with two layers of chain-link fence and two layers of nonwoven geotextile fabric that reduced the number of fragments projected from the column and their speed. The wrap contained 95 percent of the fragmentation on the test shot column. Additionally, the

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The builidng was reduced by at least half by the blast.

maximum fragment throw distance for the remaining 5 percent was 20 feet.

- Covering the first floor openings on the south and west sides, two pedestrian doors on the north side, and the first 60 feet of the east side from the north with a chain-link fence curtain and nonwoven geotextile fabric. The fence was secured at the top, but allowed to hang free at the bottom. The fabric was 15 feet high, providing enough fabric lying on the ground to secure with sandbags once installed over the fence. The fabric had enough slack to allow it to move if impacted by fragmentation and decelerate the fragment instead of allowing the fragment to pierce the fabric.
- Covering all exposed initiation system components inside the building with two layers of sandbags. This significantly reduced the chance of misfires due to components being severed from flying debris. After analyzing the results of the blast, the team thought that a single sandbag layer covering the detonation cord and a double sandbag layer over the initiator components would have been sufficient. Covering the detonation cord with sandbags also provided suppression of blast overpressure since the detonation cord was exploding in free air lying on the building floor.

KRS installed 3/4-inch plywood barricades over windows and air conditioning units in close proximity and facing the building to protect against flying debris and constructed a barricade around a nearby building.

Since the charges were positioned inside the columns, blast overpressure was not a major concern. The amount of explosives used per charge was the minimum amount needed to achieve the desired blast results. The majority of energy of the blast overpressure was directed within the borehole, resulting in breaching of the column. Once the column was breached, there was minimal overpressure remaining to impact surrounding structures or personnel.

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Ground shock was negligible due to the coral substrate, height of the structure, and amount of explosives used. It is common practice to measure vibration at surrounding buildings using a seismograph; however, the blast team did not have equipment to support this. For future operations, this might be added for research and training value. For a larger structure, seismographic measurements would be a requirement.

Conclusion

Building 708 detonated and collapsed as planned, with no damage to surrounding structures. The sequences detonated from south to north to control the fall of the structure away from nearby buildings—the building successfully fell down onto its own foundation. Portions of the building between the second and third floor stairwells that remained intact went into complete progressive collapse, showing the significance of leaving those stairwells in place. This result was acceptable since reducing the structure height by one floor brought the entire structure within reach of the hydraulic excavators for mechanical demolition. However, removing the stairwells on the second and third floors would have caused the building to completely collapse and should be pursued on future operations.

Great strides were achieved while planning for the implosion-style blast in a confined urban environment since it required nonregulation minimum distances and used nonstandard methods for employing military explosives. This experience was an invaluable training opportunity and demonstrated greatly expanded capabilities of military explosives for future operations.

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Endnote

[1]Department of Defense Directive 6055.9, *DoD Explosives Safety Board (DDESB) and DoD Component Explosives Safety Responsibilities, 29 July 1996.*

[2]Ibid.

Note: The techniques and procedures presented in this document are the opinion of the author and other personnel consulted for endorsement due to their technical background and expertise. Adherence to these techniques and procedures provided an acceptable level of safety; however, they don't guarantee a risk-free operation or address every possible situation that occurred. The blast team was responsible for addressing unexpected conditions based on technical knowledge. The use of explosives to collapse the building was inherently dangerous, but extensive control measures were followed to conduct the operation safely.