The Amazing Vanishing Act

Controlled implosion manipulates the laws of physics to reduce a building to less than the sum of its parts

BY SALLY ADEE

Two buildings were about to vanish in a cloud of smoke and thousands of onlookers choked the Las Vegas Strip. Neighboring casinos' parking garages were jammed with spectators brandishing cameras. The parking lot of the New Frontier casino, across the Strip, was home to the official demolition party. Hundreds of well-heeled spectators mingled with lawn chairs and coolers, making the place look like an upscale tailgate party. It was March 13, 2007, and both towers of the Stardust Resort & Casino were coming down.

The skeletal shell towering in front of the crowd bore little resemblance to the majestic and mythical structure that had once dominated Las Vegas' cityscape. For 50 years, the 188-foot Stardust sign had been shorthand for Vegas itself.

Now the building's gutted husk waited for the final signal from the explosives subcontractor, Phoenix, Md.-based Controlled Demolition Inc. (CDI), which had spent weeks painstakingly distributing 428 pounds of explosives among strategically chosen girders and columns inside the 1,550 rooms of the squat nine-story East Tower and the 32-story West Tower, and connecting them with just under two miles of caution-yellow detonating cord.

At 2:33 a.m., an elaborate four-minute fireworks tribute filled the sky over the Stardust. When it was over, a pyrotechnic countdown exploded down the taller building's façade while the crowd chanted along like it was New Year's Eve. With a seismic rumble, the 356-foot-tall West Tower elegantly folded in on itself. The simultaneous collapse of both towers took less time than the actual countdown, leaving only a rising wall of fat black clouds and screaming car alarms.

Implosion is the fine art of causing a building to collapse down into its own

Controlled Implosion Theory

In the aftermath of the attacks of Sept. 11, 2001, a conspiracy theory made its way through the world: Towers 1, 2 and 7 of the World Trade Center fell by controlled implosion rather than as a result of the two passenger jets that smashed into the buildings.

The proof, the conspiracy theorists charge, was in plain sight: The collapse of all three buildings was swift (Building 7 came down in 6.5 seconds) and uncannily symmetrical; the buildings sank vertically into their respective footprints; and the demolition was total, culminating neatly in a three-story rubble pile. Theorists point to a natural tendency of tall buildings to topple to the side, not into their own footprints.

Steven E. Jones, a physicist at Brigham Young University, lent scientific credibility to the theory when he hypothesized that the culprit was the controlled detonation of military-grade explosives, rather than fires caused by the two planes. But although many agree that the features of the WTC collapse bore resemblances to a controlled implosion, the theories stop at "how." Debunkers generally have the last word.

In a 2006 report, Protec Documentation Services expert Brent Blanchard tried to put the conspiracy to rest. As part of planned demolition projects, Protec had portable field seismographs in place around several sites in Manhattan and Brooklyn on 9/11. Blanchard says they did not show the "spikes" that would normally have been caused by a chain of explosions in the towers.

The last word came in the form of a spring 2008 report released by the National Institute of Standards and Technology on the collapse of World Trade Center Building 7. Three years in the making, the report concluded that the building collapse was attributable to fire, not debris damage or engineered demolition. The destruction of WTC 1 had caused a small fire that burned out several floors of Building 7. That fire caused thermal expansion in the building's beams, and the expanding beams in turn detached girders from the main columns. Overloaded, the columns collapsed, several floors pancaked (similar to what happens in implosions after the charges are detonated) and the building collapsed.

The 33-year-old, iconic Veterans Stadium in Philadelphia was imploded in a record 62 seconds on March 21, 2004, and replaced with parking lots for the city's new sports facilities.

footprint, as if a black hole in the middle absorbed its mass. After the dust clears, the debris looks like much less than the sum of the former building's parts. The physics of it looks so improbable as to be unreal.

Not all demolitions are implosions; only a few require the extreme containment that implosion imparts. Demolition, the less expensive way to bring down a building, involves cranes, wrecking balls and bulldozers, and might take weeks or months to complete.

Implosion is done for three main reasons, says Anna Chong, president of Engineered Demolition, a blasting company in Coeur d'Alene, Idaho. Implosion is best when a building is either particularly tall, has to come down on a tight schedule, or has delicate surrounding structures. "Cost is a big factor," she says. "The taller the building, and the tighter the surrounding buildings, the more costly a demolition will be."

In Las Vegas and other densely packed cities, the point of implosion is to contain as much of the mess as possible. As such, the implosion of a tall building is a bit like a supersized magic trick. Spectators are momentarily dazzled by a physics-defying display but the technical acumen and months of grueling preparation that go into its planning are hidden.

Making Magic Look Easy

Like any good magic trick, an implosion is planned long before the theatrics. The average implosion takes under 10 seconds. The preparation takes five months.

The original Stardust opened for business in 1958 as a nine-story, 109-foot building, and was augmented with the 32-story, 356-foot tower in 1989. The doors closed for the last time on Oct. 31, 2006.

In 2006, Stardust owner Bill Boyd hired CDI as the blaster and LVI Environmental Services of Nevada to be the demolition contractor. LVI, whose

subsidiary promotes itself as the nation's largest remediation firm, managed the site before, during and after implosion. It took care of the asbestos abatement, deconstruction and hauling—everything except the actual implosion.

Behind the Scenes

The first step in any tall building implosion is to strip the building down to its bare essentials, concrete and steel. The most important part is asbestos abatement—LVI hauled more than 100,000 square feet of asbestos-contaminated material out of the Stardust. The last thing any site owner wants is liability for massive clouds of asbestos dust floating through the city.

The contractors have to remove as much of the building material as possible to minimize the chances of explosive projectiles flying out during the implosion. "No one has any conception of how fast this material is moving, until that air blast thumps them in the chest," says Brent Blanchard, field operations manager for Protec Documentation Services Inc., a demolition consulting firm in Rancocas, N.J.

Once the building has been stripped, structural engineers are brought in to determine where best to plant the charges. They pore through architectural blueprints, examine the naked support and decide which explosives to use and where to put them. In rare cases, they use computer-based simulations, but Blanchard says those are rarely useful. "Structures are never built the way they were supposed to be built—never," he says. "It takes a person to walk through there and literally look at every column, a person who knows what they're looking for. They can't be replaced by computers."

Blasters tend to work bottom up; they raze the major support columns on the lower floors first and follow up with a few of the higher floors. The Stardust's smaller East Tower was typical of a 9-story building: only the first two floors needed to be wired with explosives to bring the whole structure down. That's how implosion works: it collapses one section, which weakens and collapses the section above it, and onward until the center can no longer hold.

The structure also needs to be weakened to prepare it for the implosion, so all non-weight-bearing walls are taken out. The crews notch columns and walls to make sure they succumb easily: after all, a building is not brought down by the explosions—these only weaken the supports so that gravity can do its job. Then more holes are drilled into the columns to hold the explosives.

Methods depend on where in the world a building is being imploded. Most U.S. buildings use either steel beams or concrete columns filled with steel-reinforcing bars (rebar). [For more information about how skyscrapers are built, see the fall 2007 issue of *BOSS* at www.dixonvalve.com.] Buildings in the U.K. are often constructed with shear wall, a kind of concrete not usually supported by rebar. Demolition is trickier. "You have to be careful or you'll shoot the concrete everywhere," Blanchard says. Elsewhere in the world, the concrete is less dense and supportive. In Greece and Malaysia, for example, Blanchard says, "If you rub the concrete hard enough on the ground, it will turn into powder. It's very unsafe. That's why you see all those buildings collapse when there's an earthquake."

Rebar doesn't respond to the same explosives as concrete. Concrete is no problem for conventional dynamite, which is just absorbent stuffing saturated with combustible chemicals. Once ignited, the burning chemicals quickly generate a massive amount of hot gas. That expanding gas creates enormous outward pressure, up to 600 tons per square inch, which sends a supersonic shock wave through the column and splinters it into tiny chunks.

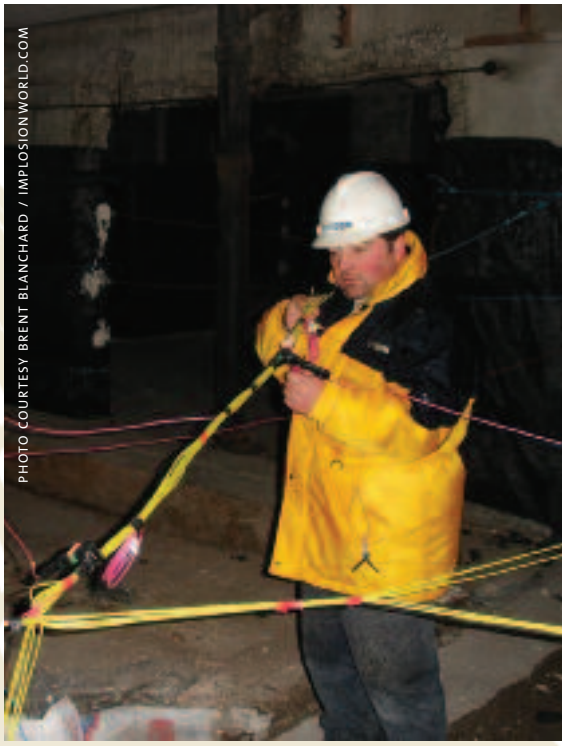

PHOTO COURTESY BRENT BLANCHARD / IMPLOSIONWORLD.COM

A worker inspects detonating cord connections before a blast in Glasgow, Scotland.

Steel beams, by comparison, are more complicated. "Steel is a lot riskier," Chong says. Severing them requires cutting the steel, which can only be done with a specialized high-velocity explosive called RDX, which is stronger than dynamite. Contractors affix the RDX in shaped charges to the steel beams. When it detonates, the shock wave tears the steel at a rate of 27,000 feet per second. The addition of a smaller amount of regular dynamite provides a nudge that encourages the beams to collapse in the right direction. Each baited floor of the Stardust's West Tower had 56 concrete supporting columns, which were perforated with 882 narrow holes. Another 339 were punched into the columns of its shorter sibling for a total of 1,221 holes. On the day of the demolition, the boreholes would receive their volatile payload: 856 sticks of nitroglycerin dynamite, connected by a long fuse to a detonator hundreds of feet away from the building.

Detonating cord is a flammable core inside a flexible plastic casing. As per cartoon physics, the contractor ignites one end, and the steady-burning flame travels along the cord until it hits the detonator at the other end, where it sets off the primary charge. The burn rate of detonating cord is incredibly fast, but also predictable, ensuring the exact timing to control multiple detonations. But once the detonator is triggered, there's no going back.

The First Blast

The 700-year-old Holy Trinity Cathedral in Waterford, Ireland, was the first recorded explosive demolition, razed in 1773 with 150 pounds of gunpowder. Explosive demolition came to the United States around the 1850s. In its attempts to save San Francisco from a rash of fires, the local government ordered the demolition of any buildings that might fuel the fire's path. Later, Alfred Nobel came up with a stable, less volatile derivative of nitroglycerin that has since become practically a synonym for explosives: dynamite. [For a biography on Alfred Nobel, see the summer 2008 issue of *BOSS* at www.dixonvalve.com.]

After World War II, blasters discovered they could control the direction of a building's fall and minimize ground vibrations—by turning one massive explosion into a staggered series of several small explosions. By the late 1940s, movie newsreels showed large structures collapsing in dense urban areas without so much as grazing anything around them. In the 1960s, RDX was added to the menu of explosives.

A convergence of technological improvements meant better explosives, better modeling and an accumulation of experienced blasting companies that had been working with explosives for decades. By the 1990s, implosion was a spectator sport. Because of the impressive physics of the operation, implosions drew major crowds. A decision that had

Apartments that were never completed are imploded in Bari, Italy, in 2005, below left. A worker connects detonating cord to explosives placed on a column in the Continental Bank building in Fort Worth, Texas, below right.

PHOTO COURTESY BRENT BLANCHARD / IMPLOSIONWORLD.COM

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PHOTO COURTESY ANDREW FERGUSON / HTTP://ANDREWFERGUSON.INFO

Fireworks lit up the sky above the Stardust Resort & Casino as interior dynamite charges began to bring down the landmark, above.

The average implosion takes under **10 seconds.** The preparation takes **five months.**

Demolition ... Quiet and Slow

Implosion's claim to fame has always been that it is the fastest and comparatively cleanest. But in 2003, a Johns Hopkins University study showed that the dust lingered, causing health concerns for surrounding neighborhoods. "It caused a bit of a buzz when it came out," says Brent Blanchard, operations manager for Protec Documentation Services. "Yes, they are harmful if you stand right next to them and breathe a lot. But you have to compare it to other methods of bringing that building down."

Last year, however, Japanese construction company Kajima Corp., headquartered in Tokyo, debuted a floor-by-floor demolition technique, called daruma-otoshi, that is anything but fast and media-friendly: a piecewise, controlled dismantling that takes a building apart like a game of Jenga. "Our method can reduce noise and dust from demolition work," says Kajima spokesman Satoshi Shigematsu. "It is also easy to recycle the materials from the building's interior."

Here's how it works: the crew knocks out the walls of the ground floor and replaces the support pillars with hydraulic metal columns. Once all the original supporting pillars have been replaced, a computer carefully and very slowly retracts the telescoping pillars until each floor has sunk to ground level. The effect is that of the building being swallowed by the earth in excruciatingly slow motion.

Shigematsu says the company removes asbestos and other hazardous materials at the same time the demolition of the bottom floor is happening. "It's hard to say which methods are more efficient," he says. "However, our method may be able to reduce some demolition period because we always remove interiors, separate and carry our waste materials from the ground floor instead of demolishing a building from the top floor with heavy equipment."

According to the company, a contractor could harvest and recycle 99 percent of building materials, since it avoids the mash-up of inseparable rubble that follows every implosion and sometimes makes it impossible to reliably recycle the steel and concrete. Overall demolition time can be cut by 20 percent as compared to demolition and implosion, and it reduces environmental contamination.

"If you have a ton of cheap labor, that's probably the way to do it," Blanchard says. "But I can't imagine it being cost-effective in the U.S."

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Both Stardust towers crumbled into their own footprints as gravity took over, above. The rubble left in the aftermath of an implosion can take months to clean up, left.

previously been based on cost and logistical factors was now influenced by the warm glow of media coverage. Implosion started to draw its own fan base.

Blasters became minor celebrities, sought for television interviews and documentaries. "We are deluged with media inquiries on a daily basis," says CDI Project Manager Stacey Loizeaux. Chong says her company has been in the media spotlight as well, especially while advising the government of Canberra, Australia, after one of the worst engineering disasters shook the country and implosions virtually disappeared from the media's glare.

On a Sunday afternoon in July of 1997, the seven-story Royal Canberra Hospital and its four-story nursing dormitory, Sylvia Curley House, were imploded to make room for the National Museum of Australia. The government was insistent on this timely implosion and had extended an official invitation to the public. The 100,000-plus who showed up formed the largest crowd in Canberra's history.

Twelve-year-old Katie Bender was at the show with her parents. Tens of thousands of spectators thronged along the shore of Lake Burley Griffin to watch the display on the other side. When the hospital came down at 1:30 p.m., a 2-pound steel fragment ricocheted about 1,400 feet across the lake, killing Katie instantly.

A subsequent inquest found that the people in charge had no experience with implosion. The investigation, in which Chong's company provided expertise to legal counsel, found that several columns on the ground floor of the hospital's main tower block were not fully sandbagged—including two columns from which the forensic examiners deduced the fatal shard came. After the Canberra disaster, almost overnight, implosions worldwide stopped being promoted as tailgate parties. Though these events still manage to attract thousands, now, specific dates and times of implosion events are seldom announced far ahead of time.

When CDI gave the sign at 2:37 a.m. to implode the Stardust Resort & Casino, four members of the Boyd family, owners of the building, pushed down the plunger on a theatrical detonator right out of an old Western film.

The aftermath of the implosion left 38,000 tons of rubble—about 2.5 feet of concrete and steel per floor. LVI spent two months cleaning up the rubble and preparing the site for the June 19, 2007, groundbreaking for the $4 billion Echelon Resort, slated to open in 2010.

But one part of the Stardust will live on. The light bulb-encrusted, 18-story sign that stood in front of the hotel will be preserved at Las Vegas' Neon Museum.

The giant sign had to be painstakingly disassembled wire by wire. Ultimately, dismantling the sign took just under a week and restoring it is estimated to cost more than $1 million—a much slower and more expensive endeavor than imploding its namesake hotel.

By the Numbers: Implosion Records

Record **Tallest Structure Imploded**

NUMBER ..... **1,217 feet**
WHAT ..... **CBC Transmission Tower (FM and TV transmission mast for Canadian Broadcasting Co.)**
WHERE ..... **Shawinigan, Northern Quebec Province, Canada**
WHEN **2001**

Record **Tallest Free-Standing Structure Imploded**

NUMBER ..... **906 feet**
WHAT ..... **Matla Nuclear Power Station Smokestack**
WHERE ..... **Johannesburg, South Africa**
WHEN **1982**

Record Shared **Most Structures Leveled in a Single Detonation**

NUMBER **20**
WHAT ..... **Stelco Steel Plant**
WHERE ..... **Hamilton, Ontario, Canada**
WHEN **1997**

NUMBER **20**
WHAT ..... **Bow Valley Medical Center hospital complex**
WHERE ..... **Calgary, Alberta, Canada**
WHEN **1998**

Record **Longest Implosion**

NUMBER ..... **62 seconds**
WHAT ..... **Veterans Stadium**
WHERE ..... **Philadelphia, Pa.**
WHEN **2004**

Record **Most Explosives**

NUMBER ..... **12,000 pounds of explosives**
WHAT ..... **Sears Merchandise Center**
WHERE ..... **Philadelphia, Pa.**
WHEN **1994**