# Bomb Damage Analysis Of Alfred P. Murrah Federal Building

**July 30, 1995**

**by Benton K. Partin**
**Brigadier Gen. USAF (Ret.)**

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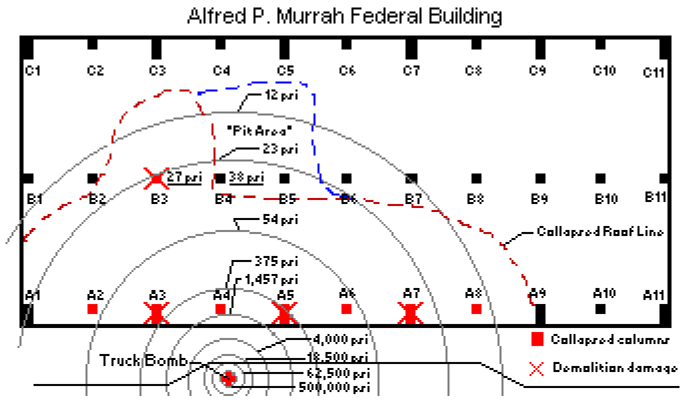


**On April 19, 1995, the Alfred P. Murrah Federal Building, Oklahoma City, Oklahoma was bombed, causing extensive damage to the structure, the loss of 168 innocent lives, the victimization of the families of those who lost loved ones, hundreds of non-fatal injuries, and substantial property damage in the vicinity. The media and the Executive branch reported that the sole source of the devastation was a single truck bomb consisting of 4,800 pounds of ammonium nitrate, transported to the location in a Ryder Truck and parked in front of the building. It is impossible that the destruction to the building could have resulted from such a bomb alone. To cause the damage pattern that occurred to the Murrah building, there would have to have been demolition charges at several supporting column bases, at locations not accessible from the street, to supplement the truck bomb damage. Indeed, a careful examination of photographs showing the collapsed column bases reveals a failure mode produced by demolition charges and not by a blast from the truck bomb. To understand what caused the damage to the Murrah Building, one needs to understand some basics about the use and nature of explosives. First, blast through air is a very inefficient energy coupling mechanism against heavily reinforced concrete beams and columns. Second, blast damage potential initially falls off more rapidly than an inverse function of the distance cubed. That is why in conventional weapons development, one seeks accuracy over yield for hard targets. That is also why in the World Trade Center bombing (where the only source of blast damage was a truck bomb) the column in the middle of the bombed-out cavity was relatively untouched, although reinforced concrete floors were completely stripped away for several floors above and below the point of the bomb's detonation (see Time Magazine, 3-8-93, p 35). By contrast, heavily reinforced concrete structures can be destroyed effectively through detonation of explosives in contact with the reinforced concrete beams and columns. For example, the entire building remains in Oklahoma City were collapsed with 100-plus relatively small charges inserted into drilled holes in the columns. The total weight of all charges was on the order of 200 pounds. The detonation wave pressure (1,000,000 to 1,500,000 pounds per square inch) from a high detonation velocity contact explosive sweeps into the column as a wave of compressive deformation. Since the pressure in the wave of deformation far exceeds the yield strength of the concrete (about 3,500 pounds per square inch) by a factor of approximately 300, the concrete is turned into granular sand and dust until the wave dissipates to below the yield strength of the concrete. This leaves a relatively smooth but granular surface, with protruding, bare reinforcement rods, a distinctive signature of damage by contact explosives. The effect of the contact explosive on the reinforcement rods themselves can only be seen under microscopic metallurgical examination. (The rods are inertially confined during the explosion and survive basically in tact because of their much higher yield strength and plasticity.) When a reinforced concrete structure is damaged through air shock**

**coupling and the pressure is below the compressive yield strength of the concrete, the failure mode is generally compressive structural fracture on one side and tensile fracture on the other, both characterized by cracks and rough fracture surfaces. Such a surface texture is very different from the relatively smooth granular surface resulting from contact explosives.**

## Analysis of Graphic Evidence

**Tab 2 is a cross section view of the building looking from the west. The very large header or cross beam is shown at the north edge of the third floor. A large but smaller header is seen at the recessed north edge of the second floor with a brace beam extending out to the large columns in Row A. The front of the whole building is glass. Tab 3 shows the architectural layout of the first floor of the Murrah Building and the location of the truck bomb with superimposed circles of roughly equal levels of damage potential. The explosive force drops rapidly (initially proportional to one over the distance cubed) as the shock front travels farther and farther away from the truck bomb. After the release wave, the shock front will propagate proportional to one over the distance squared. The maximum possible yield from 4800 pounds of ammonium nitrate would be obtained if it were in a compressed sphere and detonated from the center. That would produce a 4.4 foot diameter sphere of detonation products at about 500,000 pounds per square inch. By the time the blast wave hits the closest column, the pressure would have fallen off to about 375 pounds per square inch. That would be far below the 3500 pound compressive yield strength of the concrete. Any column or beam failure from the truck bomb would therefore have been from blast wave structural loading and not from any wave of deformation in the concrete. The basic building structure consists of three rows of columns (35 feet apart) with eleven columns in each row (20 feet apart). The four corner columns have an external clamshelllike structure for air ducts, etc. If we label the column rows A, B. and C from front to back, and number the columns 1 through 11 from left to right, then columns A2, A3, A4, A5, A6, A7, A8, and B3 collapsed, essentially vertically. Tab 2 shows a very large reinforced concrete header at the floor level of the third floor of column row A. Much larger columns extend from the header down for the odd-numbered columns, i.e., A3, A5, A7, and A9. The even- and odd-numbered columns extended from the top of the building down to the header. The foundation of the building is a heavy, reinforced concrete slab with no sub-levels. From the potential damage contours on Tab 3, and assuming the single truck bomb, the pressure and impulse for collapsed columns B4, B5 and A7 are all in the 25 to 35 pounds per square inch region. However, the much smaller and closer columns, B4 and B5, are still standing, while the much larger column A7 is down. Column B3 is down with 42 percent less pressure and impulse than columns B4. These facts are sufficient reason to know that columns B3 and A7 had demolition charges on them. Moreover, there is not sufficient blast impulse at that range to collapse any of the three. In fact, columns B2, B4 and Bs all have the sheet rock and furring strip finish still intact on the second and third floors except where damaged by falling debris. The large header across the front of the building at the third floor of Row A was not blown back into the building as one may expect from such a large bomb. The header came straight down but rolled backward 90 degrees because the columns above the header rested off center toward the back.**

## Analysis of Photographic Evidence

**A careful examination of photos showing the "A" row columns and the large header from the third floor reveals absolutely no air blast shock wave fracture, which is consistent with the pressure falloff with distance from the truck bomb. The cleaned-up building structure (Tab 4) shows that the failure line across the roof goes all the way to the ground except around columns B4 and Bs at the second and third floor levels. Reinforcement rods stripped out of beams and floors extend straight down on all floors. Columns A3, A5, A7, and B3 collapsed straight down as the apparent result of demolition charges at the column juncture with the third floor for column B3 and with the third floor level header for columns A3, A5, and A7. The even numbered columns**

**(A2, A4, A6, and A8) in Row A collapsed straight down because they were supported at the third floor by the header, which necessarily failed with the demolition of its conjunctions with columns A3, A5, and A7. When columns A2 through A8 collapsed straight down, the roof and floor fracture lines at all floors acted as an instant hinge line, which would have given all floors collapsing down a slight tug toward column row B. Because of the collapse of column B3, the floors were cropped closer to the north side of columns B4, B5, which resulted in damage by falling debris to sheet rock on columns B4 and B5 at the third floor level. The so-called "pit" area behind columns B4 and B5 was caused either by the blast from the truck bomb pushing out the ceilings of the first and second floors or from the demolition charge on column B3. From the third floor it would look like a "pit" into which much debris fell. The blast pressure in this area would have been sufficient to exceed the ultimate yield design strength of the floor. There were large areas at this pressure being held only by the floor-thick, reinforced concrete around the 20-inch reinforced concrete columns in the B row. The floor of the first floor could not be blown downward, because it was a heavy concrete slab on compacted earth. The ceilings of the first and second floors nearer the truck between the A and B column rows could also have been blown upward initially. Although the truck bomb had insufficient power to destroy columns, the bomb was clearly responsible for ripping out some floors at the second and third floor levels.**

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## Photographic Evidence of Demolition Charges

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**Turning next to the demolition charges in the building, refer to the picture at Tab 5. Here you see column A9 with no spalling as one would expect with the blast pressures involved and the decorative indents are unmarred. Note also the grooves at the top of the column and across the header. When the demolition charge on column A7 went off, the charge instantly left a 40 foot cantilevered header supporting column A8. Cascading columns and beams from above probably snapped off the end with a clear structural fracture, including rugged cracks and rough surfaces. There is a large unseen beam extending from behind the column, between the decorative groves, back to the first floor header. This beam adds considerable rigidity to the lower oddnumbered columns in Row A. Turning next to Tab 6, the stub of column B3 has been cleared, showing the bare reinforcement rods at the third floor level. The large header from the third floor level has fallen almost straight down with what appears to be demolition charge damage clearly evident to the right of column A3. The exposed reinforcement rods are clearly seen at the header end to the right of column A3. It appears that the demolition charge pulverized the header and columns out to about two feet from the juncture. Column A3 is standing there with the clean reinforcement rods clearly extended. Also, the architectural decorative band is clearly evident without blemish (indicating no blast damage in excess of yield strength). In this picture, the failure of the header at column As is still covered with rubble, and is not visible. However, the discontinuity in the slope of the header on either side of the column As location clearly shows that it failed in the region of its juncture with column As. Tab 7 shows the localized damage to the header at the position of column As, the closest column to the truck bomb crater. The end of the beam on which the men are standing shows evidence of a demolition charge at its juncture with column As. Several feet of the beam juncture appear to have been pulverized away by a demolition charge and the ends jammed together in the collapse. The blast pressure from the truck bomb would have been in the 400 pounds per square inch region, a factor of 10 below the yield strength of concrete. Tab 8 shows the localized demolition damage at the juncture of column A7 and the header. The same telltale demolition charge evidence is clear. The straight edge of the decorative grove at the juncture can be seen on both the column and the header. In my discussions with the building architect, who was on the scene as an advisor throughout much of the cleanup, he told me that the residual building was structurally sound and that the Murrah Building could have been rebuilt. This is totally consistent with the collapse of columns with demolition charges because the inflicted structural damage is more localized. Discussions above have been limited to the reinforced concrete structure of the Murrah Building. Reinforced concrete columns are hard targets for highexplosive**

**bombs. Structures that have large areas for blast loading and low mass can be destroyed at considerable range from a large blast. That is why glass, plaster, and light structures were destroyed at considerable distance from the Murrah Building, but not reinforced concrete columns. Five pounds of blast pressure will flatten most frame houses.**

## Seismograph Readings

**Much has been said about seismograph readings. Was there more than one explosion? Most people I talked to in Oklahoma City heard two explosions relatively close together. Some close by said they didn't even hear an explosion. That is not unreasonable, when you consider that getting walloped by an intense shock wave is about like being hit across the ear by a 2" x 4". One would expect the demolition charges to have had an electrical or primacord interconnect. If so, it would be difficult to separate them on a seismograph. If delays were used, they would be discrete. If a sensitivity switch was used inside the building, the explosions would have been distinct. Bomb initiations could have been easily designed to go off either simultaneously or with separation.**

## Conclusions

**The Murrah Federal Building was not destroyed by one sole truck bomb. The major factor in its destruction appears to have been detonation of explosives carefully placed at four critical junctures on supporting columns within the building. The only possible reinforced concrete structural failure solely attributable to the truck bomb was the stripping out of the ceilings of the first and second floors in the "pit" area behind columns B4 and By. Even this may have been caused by a demolition charge at column B3. It is truly unfortunate that a separate and independent bomb damage assessment was not made during the cleanup, before the building was demolished on May 23 and hundreds of truck loads of debris were hauled away, smashed down, and covered with dirt behind a security fence. When the picture at Tab 4 was made, all evidence of demolition charges had been removed from the building site (i.e., the stubs of columns B3, A3, A5, A7 and the demolished junctures at the header with columns A3, A5 and A7. All ambiguity with respect to the use of supplementing demolition charges and the type of truck used could be quickly resolved in the FBI were required to release the surveillance camera coverage of this terribly tragic event.**

## Appendix

## Biographical Notes - Benton K. Partin

**8908 Captains Row**
**Alexandria, Virginia 22308**

**Thirty one years active duty in the Air Force. Progressively responsible executive, scientific and technical assignments directing organizations engaged in research, development, testing, analysis, requirements generation and acquisition management of weapons systems. Assignments from laboratory to the Office of the Secretary of Defense.**

**Personal contributions made in the fields of research and development management, weapon system concepts, guided weapons technology, target acquisition aids, focused energy weapons, operations research and joint service harmonization of requirements. Retired as a Brigadier General.**

**White House appointed Special Assistant to the Administrator, Federal Aviation Administration. Personally designated to prepare the White Paper on the Federal Aviation Administration for the 1989 Presidential Transition Team. This included development of policy initiatives on FAA/USAF joint use of the Global Positioning System (GPS), operational life for commercial aircraft, antiterrorism, airport and airway capacity, requirements in the FAA acquisition process and FAA leadership and management development.**

**Military Command Pilot and Command Missleman with 4000 hours (37 combat.)**

**Education:**
**B.S. Chemical Engineering**
**M.S. Aeronautical Engineering**
**Ph.D. Candidate, Operations Research & Statistics (Academics Completed.)**

**Publications/TV**
**Sino-Soviet Conflict. Competition and cooperation: Risks in Force Structure Planning,**
**A Reduced Upper Limit for Sequential Test Truncation Error.**
**Frequent TV Talk Shows on the Voice of Freedom.**

**Honors:**
**Distinguished Service Medal**
**Legion of Merit thrice**
**Distinguished Graduate - Air War College**

**Community Affairs:**
**Chairman, United States Defense Committee**
**Member of the Board, In Touch Missions International**
**Member of the Board, Front Line Fellowship**
**Founding Chairman of the School Board, Engleside Christian School**
**Washington Rep. for the Association of Christian Schools International (1981-1983)**
**Chairman Fairfax County Republican Party (1982-1986)**

**Lifelong Professional Challenge:**
**Continuing studies and analyses to anticipate and forecast the future course of world military/political/economic transforming processes.**

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## Letter of support from Rodger A. Raubach Ph.D.

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**Rodger A. Raubach Ph.D.**
**P.O. Box 3042**
**Casper, WY. 82602-3042**

**18 July 1995**

**Brigadier Gen. Benton K. Partin**
**Alexandria , VA. 22308**

**Dear Gen. Partin; Earlier today I received a copy of your report on the bombing in Oklahoma City, entitled "Bomb Damage Analysis of the Alfred P. Murrah Federal Building, Oklahoma City". This report was dated July 13,1995. I read this report carefully and examined the exhibits appended to the text. Your observations and**

**photographic analysis are meticulous in the extreme , and you are to be commended for your insights regarding the effects of blast vs. distance from the detonation. The major points of the report which I believe need to be emphasized are: (1) the fact that rebar reinforcing rods were broken but appear to be embedded in concrete;(2) very little concrete appears to have been crushed by the blast. These observations alone are at extreme variance with the hypothesis of a single large truck bomb containing ANFO. For the large (4800 lb.) ammonium nitrate bomb to have caused the damage, there would be huge amounts of sand generated from the crushed concrete around the columns wherein the rebar was fractured. I took the liberty of checking with the leading concrete supplier in my area in order to confirm the compressive yield figure that you used, that being 3500 psi. What I was told about concrete was very interesting. A 3500 psi figure is extremely low for structural concrete. A properly mixed and cured structure of the type dealt with in your report would probably have a yield strength of 5600 psi. In conclusion, General, I find myself in awe of the technical achievement that your report represents. I can find no scientific flaws in either your observations or your conclusions. I am, therefore, in full agreement with the conclusion of strategically placed small explosive charges being responsible for the destruction of the building. We can only hope and pray that a few good men and women in our Congress will heed your report and take action that results in the punishment of the real guilty parties responsible for this heinous crime against the American people, and that these same few good people are able to stem the abrogation of any more of our Constitutional rights. Please keep up the good work that you are doing for your countrymen. It is an honor to be able to correspond with you on this matter and perhaps to be of some small service to our country, the Constitutional Republic, to which many of us have sworn to defend to the best of our abilities. If I may be of any further assistance, please contact me at any time. Looking forward to your response, I remain Very Truly Yours, Rodger A. Raubach Ph.D.**