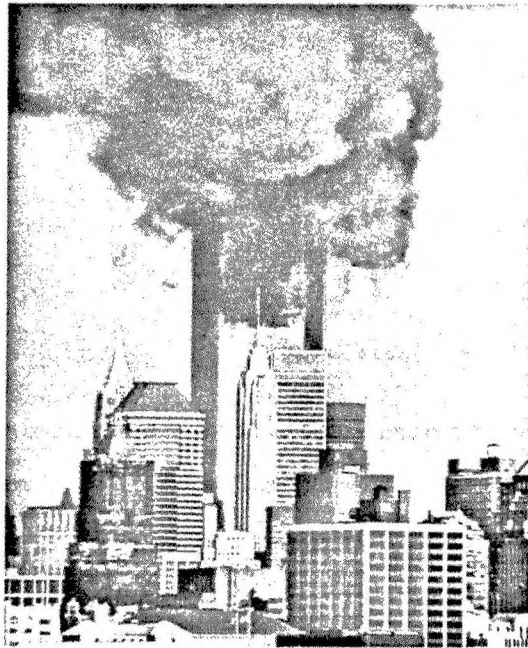


Forensic Engineering

STUDY ABSOLVES TWIN TOWER TRUSSES, FIREPROOFING



SMOKE PROOF Engineers say smoke patterns are evidence that columns failed first, not floors.

THE MOST COMPREHENSIVE STUDY YET on the destruction of the World Trade Center concludes that columns robbed of fireproofing failed first—not floor trusses—when the twin 110-story towers collapsed after being hit by terrorist plane attacks on Sept. 11, 2001. The proof is in the smoke that emanated from the burning towers before the collapses.

"There is no doubt left about the sequence of failure," says Matthys P. Levy, chairman of Weidlinger Associates Inc., the New York City-based engineer that led the study.

"Failure of the floors...was shown not to have had any significant role in the initiation of the collapses," says the report. Levy describes the floor truss system as "not unsubstantial," acting more like a membrane than a one-way system. "There was nothing wrong with it," he says. If the floor trusses had collapsed first, there would have been a mass of smoke as opposed to differentiated smoke, floor by floor, he adds.

The report also exonerates the steel's sprayed-on fireproofing. Computer models that identify the columns affect-



LEVY

blasts and attacks. Experts might also reconsider location of fire stairs and the strengthening of the core, says Levy. But he cautions, "You can never anticipate exactly what the threat is going to be."

Regarding building materials, Levy says: "Concrete is not fool-proof either."

The Weidlinger-led study was commissioned by Silverstein Properties Inc., the New York City-based leaseholder of the World Trade Center, to help support

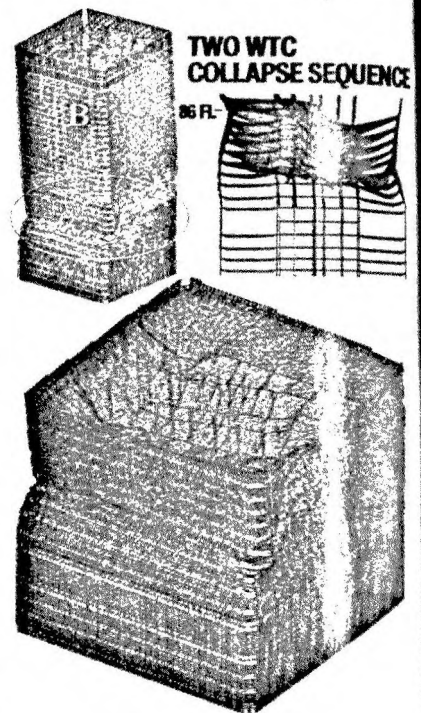
a \$7-billion insurance claim. The research team also included LZA Technology/Thornton-Tomasetti Group; ARUPFire; Hughes Associates Inc.; Safir-Rosetti; Hillman Environmental Group; RWDI; W. Gene Corley, who led the ASCE-FEMA WTC study; Professor Sean Ahearn;

ed by the planes' impacts and flying debris confirm that columns with intact fireproofing did not succumb to the jet-fuel-triggered fire. The report also says, of the fireproofing knocked off the steel, that "no fireproofing is designed to withstand such devastating impacts."

Levy echoes preliminary reports. "The buildings were well-designed, rugged and withstood a tremendous impact," he says. "The fact that they did not collapse on the planes' impacts saved tens of thousands of lives."

Questions brought into the limelight by Sept. 11 include whether there is a better way to fight fires in tall buildings, says the engineer. "It's always been a problem," says Levy.

Another issue is whether less-frangible fireproofing should be considered for steel structures considered vulnerable to



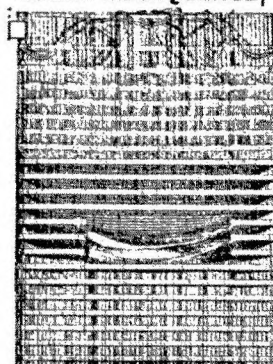
FIRST DOWN Plane took out corner of core, which hastened collapse.

and Z-Axis Corp.

Silverstein's insurers claim the collapse of the south tower, Two WTC, rendered the north tower, One WTC, unsalvageable even before it collapsed. If they prevail, Silverstein would receive only \$3.5 billion (ENR 10/7 p. 11).

The insurers commissioned their own engineering study, written by Exponent Failure Analysis Associates Inc., Los Angeles. Also released, the report disagrees with the Weidlinger findings, but mostly on points relating to the insurance battle. Engineers from Wiss, Janney, Elstner and Associates Inc., North-

ONE WTC COLLAPSE SEQUENCE



SECOND DOWN North tower lasted longer due to impact site.

PHOTO BY TOM SAWYER FOR ENR. GRAPHICS COURTESY OF WEIDLINGER ASSOCIATES INC.

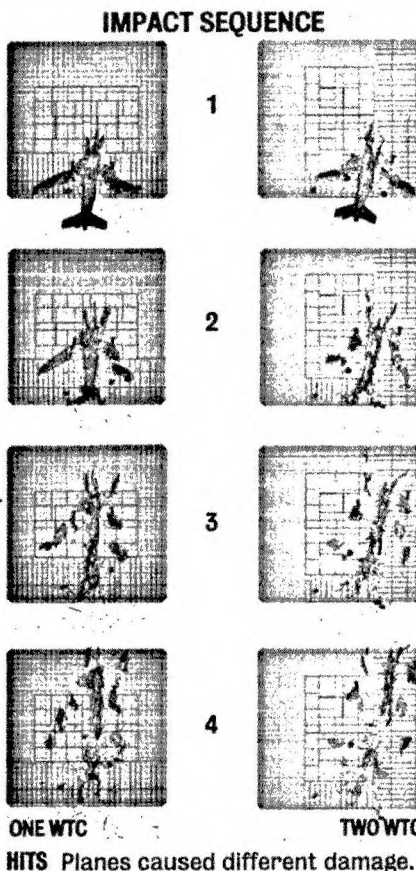
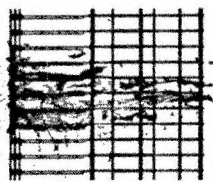
brook, Ill., also working for the insurers, would not comment on their work.

In the Silverstein study, engineers put forth similar but not exact failure scenarios for both towers: The planes and flying debris hobbled the buildings at the zones of impact. Intact columns, their fireproofing knocked off by flying debris, ultimately lost strength and failed in the fuel-triggered fire.

Though hit by the second plane later than One WTC, Two WTC fell first, "primarily" because the plane struck it off-center and at an angle and caused damage that compromised the southeast corner of the core. "This confirms an earlier theory," says Levy.

At each tower, exterior wall and core columns, connected by a steel "hat truss" at the building's top, initially redistributed loads away from the damaged areas to remaining columns. In Two WTC, the hat truss eventually could not deal with the situation of the corner columns gone, says Levy.

The team determined that the initial hits destroyed 33 of 59 perimeter columns in the north face of One WTC and 29 of 59 perimeter columns in the



HITS Planes caused different damage.

south face of Two WTC. Computer analysis showed that the impact of the planes also destroyed or disabled some 20 of 47 columns in the center of the core of One WTC and some five of 47 columns in the southeast corner of the core of Two WTC.

The Silverstein findings are based on analysis of original structural drawings, thousands of photos and dozens of videos. The team used computer modeling, including a program called FLEX developed by Weidinger for the Dept. of Defense, and fire evaluation techniques to simulate the condition of each tower at critical times, creating impact and collapse sequences.

The National Institute of Standards and Technology, which recently began a two-year technical study on the World Trade Center disaster, is using both team's studies to perform a "very systematic" analysis, says S. Shyam Sunder, chief of NIST's materials and construction research division, Gaithersburg, Md. "The real question is whether there was one dominant failure mechanism or a combination," he adds.

By Nadine M. Post

Transportation Planning

BATTLE OVER PROPOSED USE OF BONDS FOR GEORGIA CONTINUES

THE SALE OF BONDS BACKED BY FEDERAL highway funds to finance an ambitious state highway program in Georgia is on hold until the Georgia Supreme Court rules on their constitutionality.

Opponents of Georgia's plan to issue such bonds, led by a group called the Northern Arc Task Force, took their case to the state Supreme Court after a lower court ruled in September that the plan does not violate the Georgia Constitution. Briefs were filed Oct. 27 before the state high court and oral arguments are scheduled for January.

The crux of the dispute is a joint resolution between the Georgia Dept. of Transportation and the State Road and Tollway Authority. The resolution allows the DOT, the recipient of federal highway funds, to guarantee the authority's bonds. That, say opponents, is expressly forbidden by a 1972 amendment to the state constitution.

SRTA wants to issue Federal Highway

SAMPLING OF ARC PROJECTS:

- ▶ Addition of high-occupancy vehicle lanes to several Interstates
- ▶ A new intermodal passenger station in downtown Atlanta
- ▶ Commuter rail connector between Macon and Atlanta
- ▶ Northwest corridor fixed guideway construction

Source: Atlanta Regional Commission

Grant Anticipation Revenue bonds to help finance projects in the \$5.3 billion Atlanta Regional Transportation Infrastructure Plan, released Oct. 23. It includes highway and transit projects through 2005. SRTA plans to issue \$822 million, but opponents intervened with a petition filed Aug. 6 with the state district court (ENR 9/9 p. 35).

"We've got the money to fund the

projects as long as the bond program holds up," says Charles Krautler, executive director of the Atlanta Regional Commission. "There are ways to address this and get the money flowing."

Former Georgia Attorney General Mike Bowers, the attorney for the opponents, says the state's position that a joint resolution is not a binding contract is "patently" absurd. "What the government is doing is a sham," he says. Either way, the scheme is unconstitutional, he says. "If the joint resolution is a contract then the bonds are invalid because the joint resolution is expressly prohibited by [the] Georgia Constitution," Bowers says in the brief submitted to the high court. If, on the other hand, the joint resolution is not a contract, then the transfer of the federal funds from the agency to the authority is a gratuity also prohibited by the state constitution, he says.

Attorney General Thurbert Baker argued that the joint resolution is not a contract, is not binding and therefore not unconstitutional. District Judge Rowland W. Barnes agreed in the September ruling. "The question is whether the road projects that would be built under the financing scheme is a public purpose from which great benefits are expected," Barnes said in his ruling.

GRAPHICS COURTESY OF WEIDINGER ASSOCIATES INC.