

materials have significantly higher concentrations of fuel. At the burning rate necessary to yield these fires, a fuel load of about 5 psf would be required to provide sufficient fuel to maintain the fire at full force for an hour, and twice that quantity to maintain it for 2 hours. The air needed to support combustion would be on the order of 600,000–1,000,000 cubic feet per minute.

Air supply to support the fires was primarily provided by openings in the exterior walls that were created by the aircraft impacts and fireballs, as well as by additional window breakage from the ensuing heat of the fires. Table 2.1 lists the estimated exterior wall openings used in these calculations. Although the table shows the openings on a floor-by-floor basis, several of the openings, particularly in the area of impact, actually spanned several floors (see Figure 2-17).

Sometimes, interior shafts in burning high-rise buildings also deliver significant quantities of air to a fire, through a phenomenon known as “stack effect,” which is created when differences between the ambient exterior air temperatures and the air temperatures inside the building result in differential air pressures, drawing air up through the shafts to the fire area. Because outside and inside temperatures appear to have been virtually the same on September 11, this stack effect was not expected to be strong in this case.

Based on photographic evidence, the fire burned as a distributed collection of large but separate fires with significant temperature variations from space to space, depending on the type and arrangement of combustible material present and the available air for combustion in each particular space. Consequently, the temperature and related incident heat flux to the structural elements varied with both time and location. This information is not currently available, but could be modeled with advanced CFD fire models.

Damage caused by the aircraft impacts is believed to have disrupted the sprinkler and fire standpipe systems, preventing effective operation of either the manual or automatic suppression systems. Even if these systems had not been compromised by the impacts, they would likely have been ineffective. It is believed that the initial flash fires of jet fuel would have opened so many sprinkler heads that the systems would have quickly depressurized and been unable to effectively deliver water to the large area of fire involvement. Further, the initial spread of fires was so extensive as to make occupant use of small hose streams ineffective.

Table 2.1 Estimated Openings in Exterior Walls of WTC 1

Floor	North Wall		South Wall		East Wall		West Wall		Total Area	
	ft ²	(m ²)	ft ²	(m ²)	ft ²	(m ²)	ft ²	(m ²)	ft ²	(m ²)
92	743	(69)	0	(0)	1,572	(146)	0	(0)	2,314	(215)
93	958	(89)	0	(0)	1,356	(126)	0	(0)	2,314	(215)
94	592	(55)	54	(5)	1,163	(108)	0	(0)	1,808	(168)
95	1,055	(98)	54	(5)	0	(0)	420	(39)	1,528	(142)
96	797	(74)	151	(14)	0	(0)	1,518	(141)	2,465	(229)
97	926	(86)	151	(14)	0	(0)	1,798	(167)	2,874	(267)
98	1,335	(124)	0	(0)	0	(0)	0	(0)	1,335	(124)
TOTAL	6,405	(595)	409	(38)	4,090	(380)	3,735	(347)	14,639	(1,360)

NOTE: Differences in totals are due to rounding in the conversion of square meters to square feet.