

BLAST LOADING AND CLEARING ON TALL BUILDINGS

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Abstract. The impulse delivered to the surface of a building by a blast wave travelling perpendicular to the building surface is not usually the fully reflected impulse produced on an infinite surface. Instead, it is lessened by “clearing” as expansion waves propagate inwards from the regions of lower pressure at the building’s edges. The actual time-varying load delivered to any point on the building surface can be approximated by an instantaneous rise to the reflected (or oblique reflected) pressure followed by a positive phase foreshortened by the arrival of the expansion wave. The assumption in this clearing model is that building surface dimensions are similar, ensuring that reflected pressures are achieved across the whole surface parallel to the blast wavefront. For a tall building whose height is considerably greater than its width, expansion waves originating from the sides of the building will propagate inwards and reduce the (oblique) reflected pressure as the blast wave progresses up the building. This paper illustrates the phenomenon of clearing on tall buildings, identifying the key factors that govern the process. Results of numerical simulations are presented, supported by small-scale experiments in which a broad range of important parameters, such as stand-off and building width, were investigated.

INTRODUCTION

When a solitary building is loaded by a blast wave generated by a high explosive charge detonated at a relatively large distance from the building and travelling in a direction perpendicular to the front face of the building, the blast wave will have very little curvature. It can be considered to be a plane wave and the whole surface of the building will be subjected to an almost instantaneous rise to the peak reflected overpressure, p_r . This “far field” loading is illustrated in Figure 1. If the same building is loaded by a blast wave originating from a much closer detonation, some of the face of the building will be loaded obliquely, and the peak pressure at any given point will be $p_{r\alpha}$, the oblique reflected pressure, which is a function of the incident pressure and the angle of incidence, α . This “near field” loading is illustrated in Figure 2. In both figures, the angle α (measured from the horizontal to the top of the building) is the angle between the ground and the dashed line.

The key features of this scenario are that the buildings are *finite* and the dimensions (width and height) of the front of the building (facing the blast) are *broadly similar*. In other words, the dimensions of the building are sufficiently small that the wave does not decay completely before it reaches the edges, and the dimensions are sufficiently similar that expansion waves (producing clearing) occurring at the edges do not progress significantly before the whole of the surface is loaded by the incident wave. This ensures that reflected (or oblique reflected) pressures are achieved across the whole of the face of the building. This process is described as “normal” clearing and can be found in the references below.

A reasonable approximation of the impulse exerted on the surface of a finite building can be calculated from knowledge of the reflected pressure, positive phase duration and the time taken for the expansion waves to traverse the building surface, which is usually expressed as a “clearing time”, t_c . Several methods for normal clearing are based on the use of this information, including Glasstone and Dolan [1], TM5-1300 [2] and ConWep [3].

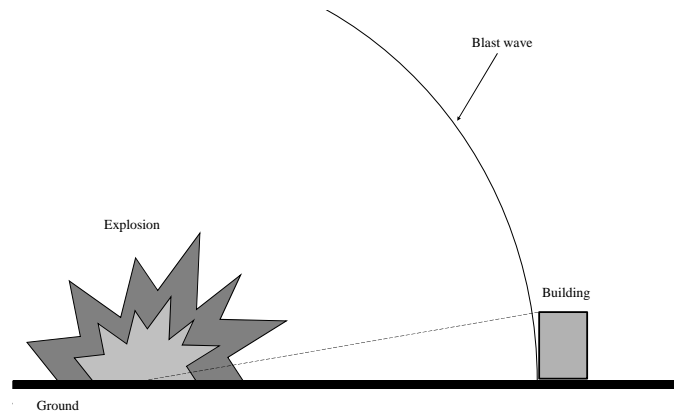


Figure 1. Blast wave loading of a finite building in the far-field by an almost plane wave.

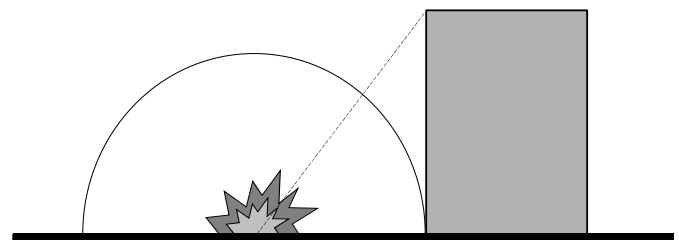


Figure 2. Blast wave loading of a finite building in the near field, oblique reflection.

The problem with the methods described in References [1] and [2] is that they rely on the far-field, plane-wave scenario of Figure 1 and only use one value of p_r and t_c to calculate the average impulse. ConWep [3] calculates many values of $p_{r\alpha}$ and so can also treat the near-field problem of Figure 2, although it still only uses a single value of clearing time. Similarly, the extensive range of “clearing factors” developed by Rose and Smith [4] is only valid for buildings with a limited range of height-to-width ratios.

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