Shear in concrete elements subjected to blast loads

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Concrete elements subjected to intense dynamic loads have been reported to fail in shear, even if they are designed to fail in a flexural mode under static loads. A flexural response with yielding of the reinforcement is always preferrable over a shear damage response with a limited deformation capacity. This is the case for conditions with static loading and is certainly also the case under dynamic loads. In this paper, dynamic loads refer to blast loads with an almost instantaneous increase in pressure with a subsequent pressure relief over time. Such an intense load may cause a structural element to vibrate in several bending modes above the fundamental mode of vibration, which imposes a higher degree of shear demand in the element.

Previous experiments and analyses have provided a greater insight and understanding of shear failures in concrete elements subjected to blast loads. The purpose of this paper is to present the findings of a few selected experimental campaigns and also to discuss the results from the corresponding analyses.

Since shear damage can occur at an early stage of an element's response, it is of interest to analyse the initial behaviour of the element soon after the load has been applied. The distributions of the deformations, the bending moments and shear are initially significantly different from those in static events and show large variations both in time and space. Analyses of these initial variations provide a better insight into where cracking and failure due to flexure and due to shear may appear. Such analyses will be discussed in the paper along with the evolution of shear failures.

For static loads, it is well known that the shear slenderness has an influence of shear in concrete elements. Depending on the shear slenderness, different shear failure modes for a sufficiently large loads may occur. This shear slenderness is, however, not well-defined in a dynamic case due to the large variations in deflections, and flexural and shear stresses in space and time. Actually, the shear slenderness varies throughout the response, and these issues will be discussed in the paper. Other aspects that influence a shear behaviour are element cross section, reinforcement, and load amplitude and duration. Some of these aspects will also be addressed.