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Uncertainties of Explosion Loads and its Influence on Reliability

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Summary

This paper presents different aspects of uncertainties concerning the estimation of accidental loads caused by an explosion of dangerous goods in transport and its influence on the reliability of structures. Both physical and statistical uncertainties are discussed. The physical uncertainties about explosion are described concerning both the character of the source which drives the blast wave as well as environmental conditions: free-field explosions and explosions in fields with some degree of confinement or occurrence of obstacle. Uncertainties concerning estimation of probabilities of explosion using available statistics about reported accidents are discussed. Some sources of faults or misjudgements caused by using statistical information about low-probability events are highlighted. Methods suitable for use in cases of limited data availability are presented. Finally - the structural response, damage criteria and reliability of the structure are discussed.

Keywords: explosion; dangerous goods; statistics; uncertainties; low-probability event.

Abstracts

The lifetime of structures we design and construct today makes it obvious that we build for future generations. Structural safety must be sufficient, but on the other hand, because of economic reasons and concerning the inevitable use of natural resources, the structure must be optimised. After years of research and laboratory tests we can quite exactly predict the resistance of the structure. Unfortunately, the value of loads and especially accidental loads acting on the structure can not be predicted with the same accuracy neither concerning the probability of occurrence of a load nor its magnitude.

The values of loads are necessary for the estimation of the safety level of the structure and comparison with the demanded safety. Applying reliability theory makes it possible to handle uncertainties in this problem. However, reliability is a function of the information used in the analysis.

This paper describes some aspects of physical and statistical uncertainties about blast wave caused by an explosion of dangerous goods in air. As an introduction, the structure of the ideal blast wave is described in general terms. Differences between characteristics of the blast wave caused by explosive substances as TNT and fuel-air-mixtures are presented.

Some general uncertainties of estimation of the value of the load, as:
- the model uncertainties connected with use of the TNT model,
- metrical uncertainties of measurement of pressure with great magnitude and
- translational uncertainties of interpretation of results of small-scale laboratory tests are pointed out and described.

The physical uncertainties of explosion concern both character of the source, which drives the blast wave and the environmental conditions at the place of the explosion. The influence of the environmental conditions on the phenomena of explosion is described in brief concerning free-field explosions, explosions in fields with some degree of confinement or occurrence of obstacles. The result of the computer calculation of the detonation of 333-kg of TNT in the centre of a tunnel is illustrated.

Statistical uncertainties concerning probabilities of an explosion are discussed. As a rule, probabilities of explosive events are estimated using statistics about reported accidents. Some sources of faults or misjudgements caused by using statistic information about low-probability events will be highlighted. Application of some methods useful for the analysis under conditions of limited data availability as Fault tree and Beyesian Analysis is illustrated.

Finally – specification of the requirements according to the codes as well as the damage criteria are presented. The appropriate degree of the reliability of a structure in regard to the possible consequences of failure and the cost of safety measures are discussed. Some guidance about the character of the loads as well as certain types of construction, which can be recommended, are presented.

Influence of the local character of the explosion load on the principles of the design of tunnel structures is pointed out.

Some guidance about good practice of the design of structures to provide an adequate margin of safety against catastrophic collapse is presented.