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Disaster of an industrial hall caused by an explosion of wood dust and fire

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ABSTRACT

This article scrutinises a disaster affecting an industrial hall built of prefabricated reinforced concrete. As a result of an explosion of technological equipment used in the woodworking process, the entire pretensioned prestressed concrete girder structure, as well as the roof slabs, was badly damaged. Additional damage was caused by the high temperature generated by the resultant fire, as well as rapid cooling due to fire-fighting activities. Increased air pressure and the ensuing shock wave caused extensive damage to the brick walls in the neighbouring technology rooms. The explosion caused deformations of a brick chimney located more than 100 m from the blast zone. Subsequent investigations showed that a lack of adhesion of the tension members in the contact zone with an incoherent concrete structure could have led to a complete destruction of the covering structure. In the degraded girders located directly above the explosion area, a gradual loss of the prestressing force was observed. To prevent spreading of the disaster, ad hoc operations to protect both the structure of the building and the remaining technological equipment were developed. The girders located directly in the explosion zone were temporarily propped up and prepared for immediate removal. The article also presents an account of the reconstruction of the damaged building. In place of the removed prestressed girders, a light cover supported on truss steel girders was designed. The investigations that followed confirmed that an immediate cause of the hall's damage was destructive processes triggered by the self-ignition of a mixture of wood dust in the improperly ventilated wood processing machinery. The resultant flame brought about a secondary explosion of the dust accumulated in the hall. The lack of proper human supervision of the industry control systems additionally increased the extent of the damage and financial losses.

1. Introduction

Technological processes making use of combustible materials pose a potential risk of explosion, which may not only lead to the destruction of equipment but also damage buildings or industrial engineering structures. Examples of the effects of a number of disasters caused by explosive dusts of various composition were described in detail by Abbasi and Abbasi in [1].

The explosion of technological equipment used in the woodworking process initiated a construction disaster of a prefabricated industrial hall built of reinforced concrete located in Poland, central Europe. As a result of the shock wave that immediately followed, the high temperature of the resultant fire, and the subsequent cooling and thermal shock resulting from

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fire-fighting action, the concrete in the structural elements was deprived of its elastic properties, which could have ultimately led to the spread of the disaster and total collapse of the hall.

As the catastrophe occurred at night, during the non-stop automated technological process, there were no casualties, but many workers and a number of the fire-fighters were seriously injured. The negligence of the workers supervising the technological process of the manufacturing of the furniture chipboards, as well as the poor technical condition of the fire-fighting equipment, contributed to the increase in the scope of the damage and financial losses to the proprietor.

An overview of the halls' constructional damage is shown in Fig. 1.

2. Analysis of the constructional design

The technological halls of the chipboard manufacturing plant, including the chipboard forming and pressing hall where the explosion occurred, had been built of prefabricated reinforced concrete material. The width of the naves was 18 m, whereas their heights varied from 7.20, 9.60 to 12.40 m. The covering elements, i.e., precast reinforced concrete slabs and steel skylights, were laid on pretensioned prestressed concrete girders. The girder reinforcement, made of ten wire strands each composed of seven strings 5 mm in diameter, was suited to the loads resulting from snow weight and the weight of the skylights, roof slabs and technological installation located above the roof. The girders rested on specially prefabricated openwork reinforced concrete columns with a cross-section measuring 80 × 40 cm each. Single element cross sections measured 25 × 40 cm, and the columns were spaced every 6 m.

The outer walls were built of prefabricated reinforced concrete slabs insulated with Styrofoam. Adjacent aisles were separated with specially prefabricated reinforced concrete panels of increased fire resistance. The gable walls between segments of varying height were made of autoclaved aerated concrete (AAC) blocks, each 24 cm thick, mounted on the upper shelves of the pretensioned gable girders.

The cross-section of the structural elements of the industrial hall, indicating the location of the equipment and technological installation, is shown in Fig. 2.

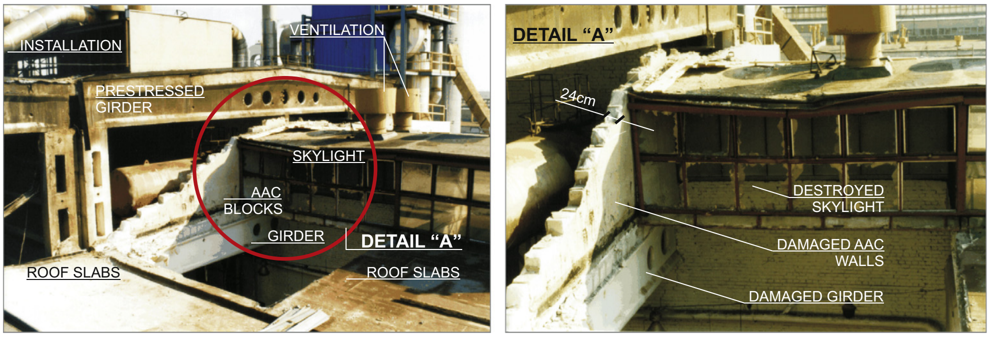

Fig. 1. Overview of the collapsed hall's construction.

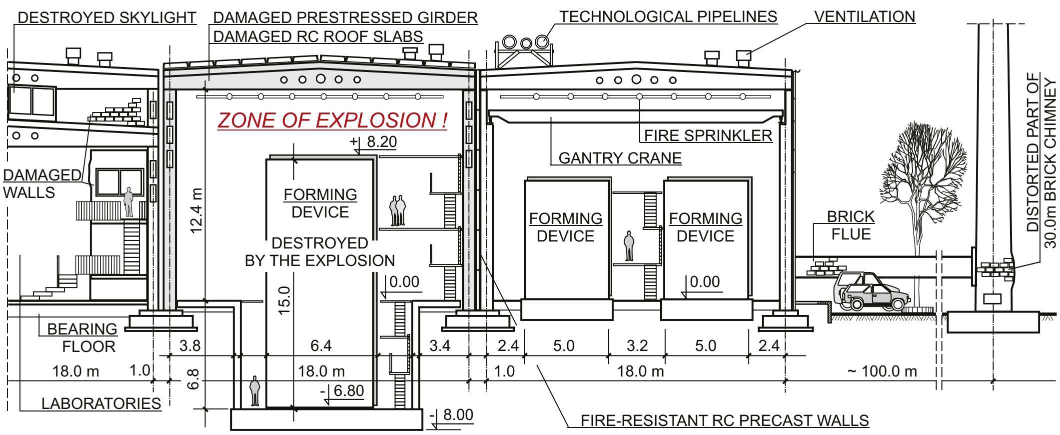

Fig. 2. Cross-section of the industrial halls and the arrangement of the structural elements.