THE SIMULATION OF AN INDUSTRIAL BUILDING DEMOLITION

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Abstract. The paper present a way of checking and optimization of a demolition scenario at an industrial building based on controlled blasting method in order to transition to the actual demolition of the building in question. For this purpose we used a specialized computer system that describes the behaviour of the structure at exceptional actions, from the application of forces, the opening and propagation of cracks, the separation structural elements up to total collapse of the building.

Key words: blasting controlled, modelling, applied elements method.

1. Introduction

The explosion and urban modernization in recent years, were premise generally the opportunity demolish in our country at many old buildings. From the methods of demolition of buildings, due to reduced work time and low expense with labour, the demolition by blast works is the most competitive method. This method ensures a high level of security.

Globally there are specialists who are able to perform blasting in restrictive safely extremely, but published documentation in this area is very limited because the methods of calculation and the accumulation experience are considered secret by the company. In most cases, the presentations of extremely difficult demolition have an advertising purpose and scientific introduced data are extremely limited. The explosion energy use research at controlled buildings demolition involves knowledge of different fields such as physical explosion, the detonated and earthquake engineering. Such research of these disciplines can produce remarkable results only under close cooperation between specialists in these areas and allocation of adequate resources.

Following the rapid development of computers, in the world appeared different computer programs mainly based on finite element method. Such a computer program, that combines features of finite element and discrete element method is used to study the behaviour of the demolition by controlled explosions of industrial buildings.

2. The characteristics of structure and the land

The construction analysed for the demolition is an industrial building. This is spatial structure of reinforced concrete, the strength structure being formed of columns and beams stiffened by ceilings.

The construction has a rectangular shape in plan with dimensions 28.20 x 9.25m, with the height regime P+5E+2R (31.90m height) and is composed of two bodies without expansion joint between them. The first block building has dimensions 12.20 x 9.25m and the height regime GF +5 F +2 R (31.90m) and other one 16.00 x 9.25m and the height regime GF +5 F (24.50m) (Fig. 2).

The resistance structure is made of reinforced concrete frames composed of columns (with dimensions 0.75 x 0.75m on the ground floor and 1st floor 0.65 x 0.65 m respectively on the 2nd floor), beams (0.35 x 1,00m and 0,45 x 0, 70m on the ground floor, 0,60 x 1,00m and 0,45 x 1,00m on the 1st floor) and concrete ribs (0,25 x 0,40m and 0,20 x 0, 30m).

The columns layout and their dimensions are shown in Fig. 1. The structure is modulated on a single opening 9.00m and 5 beams x 3,5m for the building part having height regime GF+5 F respectively 2 openings of 4.50m and one beam x 6,00m for the other side of the building. The ceilings technological by reinforced concrete are at the following rates: 3.50m, 7.00m, 11.50m, 16.00m, 20.50m, 25.00 m and 28.70m. The roof is of reinforced concrete caisson type for body of building GF+5F and plate reinforced concrete for body of building with height GF+5F+2R, both of which equipped with thermal insulation and waterproofing.

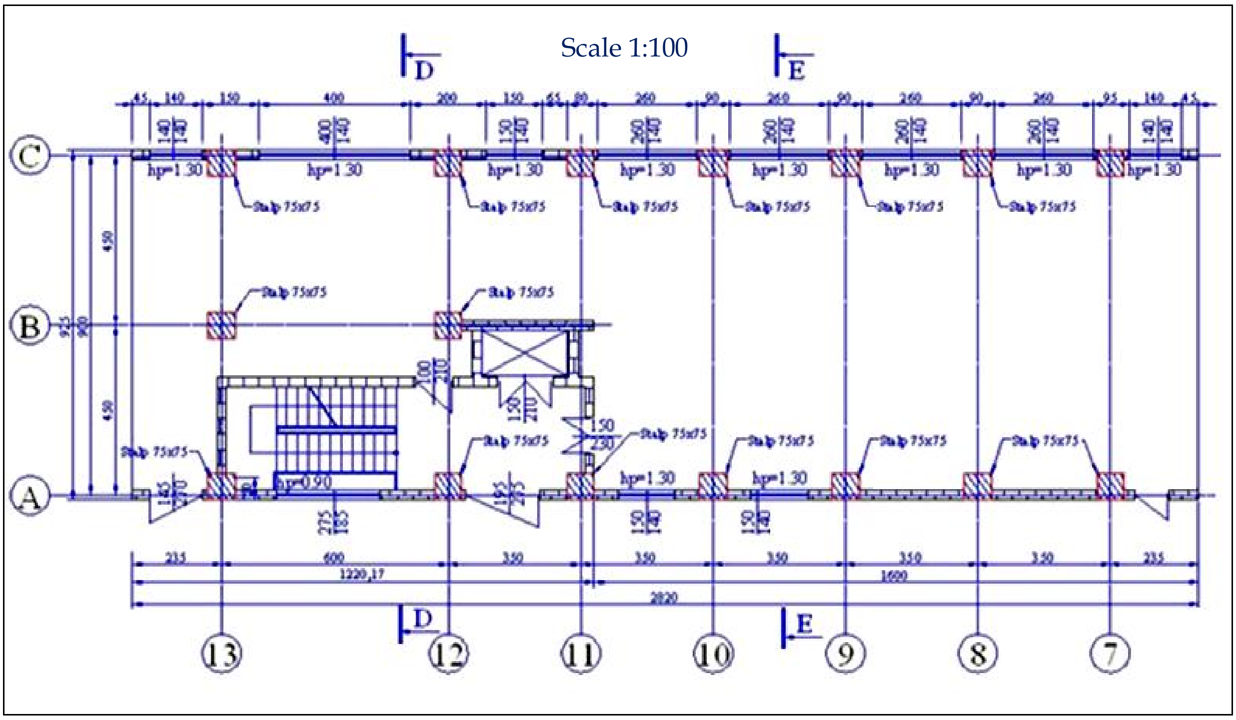


Fig. 1. The ground floor plan of the building proposed for demolition

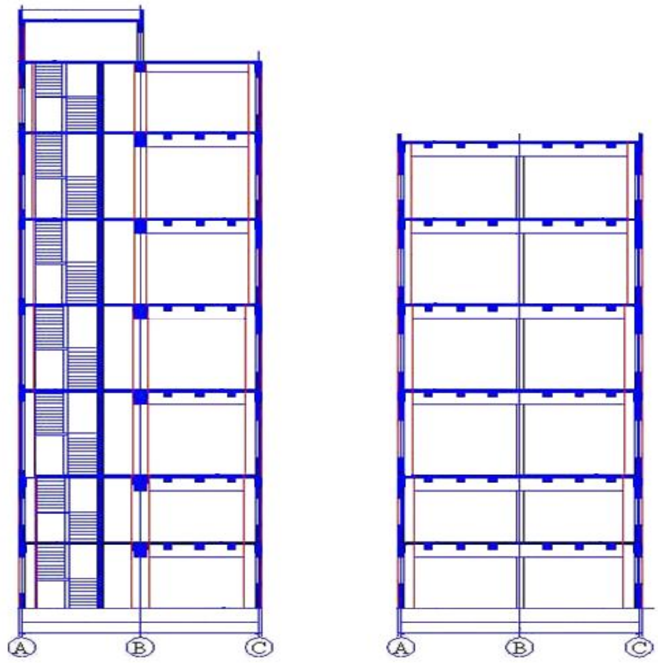


Fig. 2. The cross sections of the building under demolition

The access to the upper floors is achieved by stairs and elevator. The closures are made of brick walls and glass. Near the structure studied, at about 30m is located many blocks of flats that must be protected from the effects of the demolition action.

3. The analyse of structure behaviour at the demolition with explosives

To analyse the behaviour of the structure in question at the demolition by blasting, we have used The Applied Element Method, combining features of finite element method with discrete element method. The time for the complete analysis is reasonable and the accuracy of the results is satisfactory.

In literature there are many articles that contain studies emphasising this aspect (Tagel-Din and Meguro, 2000; Meguro and Tagel-Din, 2002; Tagel-Din and Rahman, 2006; Izzuddin *et. al.*, 2008; Lupoae and Bucur, 2009). The applied element method, owing to combinations of elements, may very well surprise appearance and development of plastic hinges and also the separation of elements, making it possible to analyse the behaviour of structures in different scenarios: the controlled demolition, the impact, the explosion, etc. Thereby two elements are connected by a series of points. At each point are attached three springs namely one normal spring and two shear springs. Each spring represents the deformations, specific deformations and the unitary efforts for some part of the structure. Separation of elements occurs when is exceeded a certain value for the specific deformation (Fig. 3, 4). The constitutive adopted model for concrete in computer program who are based on element method applied.

Extreme Loading for Structures (ELS) is shown in Fig. 5. For modelling the concrete compressive is used Maekawa model (Okamura and Maekawa, 1991). In this model (Fig. 5.a) are introduced the following parameters to define compressive strain and deformation envelope, Young's modulus, the rupture parameter, which represents the degree of concrete internal destruction and the plastic compressive deformation. In this way both the load and unload curves can be described quite well.

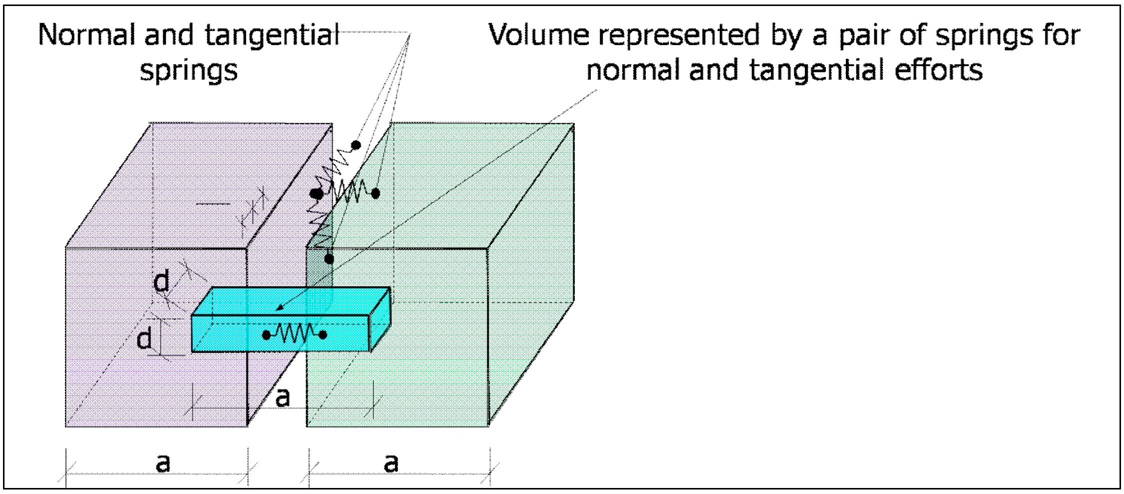


Fig. 3. Connecting of elements in Applied Element Method

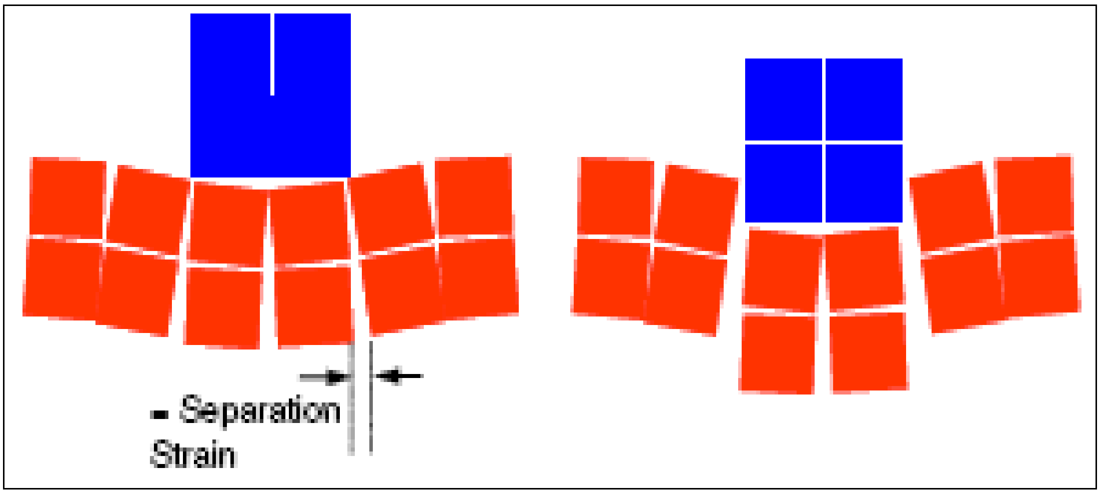
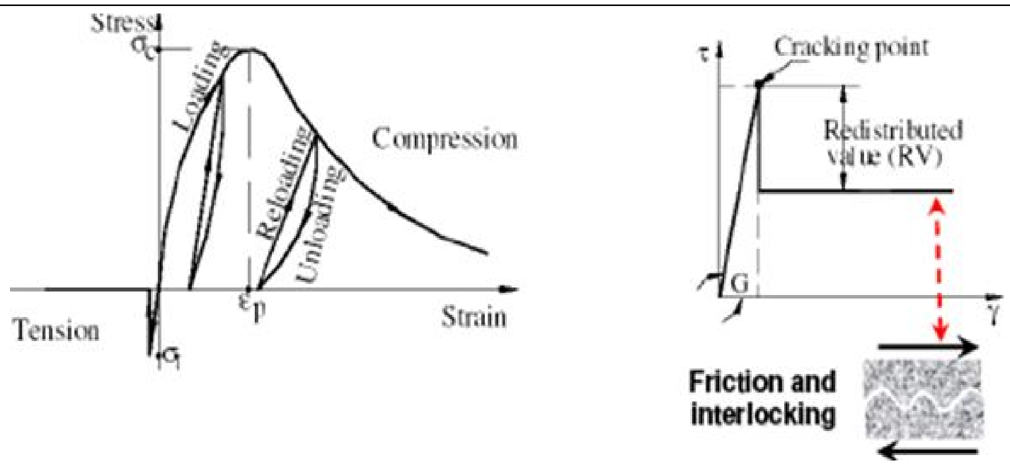


Fig. 4. Split of elements in Applied Element Method



a) Concrete under the action of axial efforts.

b) Concrete under the action of tangential efforts.

Fig. 5. Concrete constitutive model implemented in ELS

The transverse modulus of elasticity can be computed in according with deformation in the spring positioning. For the springs that describe the reinforcement behaviour, is used the Ristic model (Ristic *et al.*, 1986).

The reinforcement stiffness is calculated based on the spring deformation associated reinforcement, state of charge (either loading or unloading) and the time evolution of the steel, which controls the Bauschinger effect (Fig. 6).

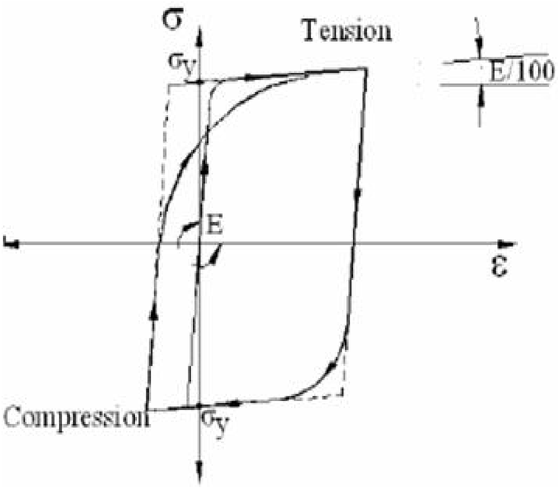


Fig. 6. The armature behavior at the axial force

In this model it is assumed that the crack concrete, when the main strain reaches the tensile strength limit of the concrete. After cracking, there are two ways of dealing crack if no belongs to a surface element:

1) dividing of the element into two elements and generating new springs between crack surfaces;
2) leaving element as it is and redistribution the efforts resulting by cracking.

The first method is generally more accurate but it is very laborious and time consuming especially when analysing complex structures and the problems of progressive collapse. The other side method is not as accurate but lead to the reasonable results. If the concrete behaviour is governed by transverse cracks then it is recommended to reduce the size of the item to allow the formation of cracks as accurate.

4. Making geometric model of structure

The geometric model of structure is presented in Fig. 7.a. To achieve geometric model have been defined styles for each type of columns, beams and closing elements.

a) The geometric model of structure b) Real structure

Fig. 7. Simulated and real structure before demolition

5. Introducing demolition scenario

This step is to specify the structural elements, the order and time at which they are to be removed. The order of destruction of elements of construction is shown in Fig. 8 and was designed after dimensioning of parameters to the industrial building demolition (Table 1). In this stage it also indicates the total time of analysis and the time step. For this analysis we used two values for time step: a time step at 0.001 s for to the capture the behaviour of the structure between the two stages of explosion (the interval between two successive explosions was 0.25 μs) and a time step at 0.01 s to check the direction of fall and the mode the destruction of the building.

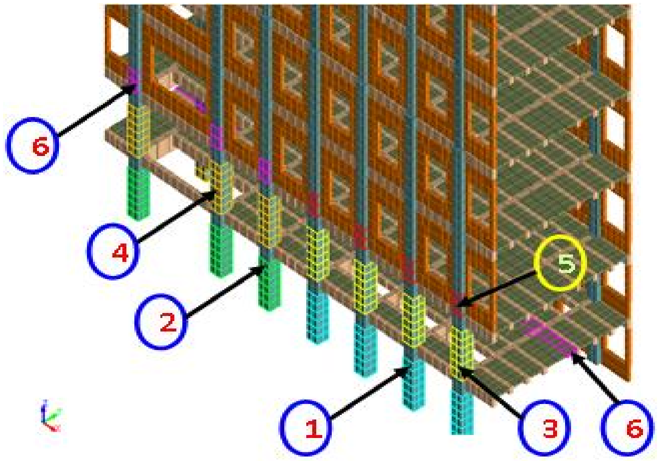


Fig. 8. The steps of blasting

Table 1. The blasting parameters of the industrial building

<table>
<tr><th>The blasting parameters</th><th>The columns [1] 0,65x0,65m</th><th colspan="2">The columns 0,75X0,70m</th><th>The columns 0,45x0,70m</th><th>Beams 0,35X1,0m</th><th>Beams 0,60x1,00m</th></tr>
<tr><td>G_{tr}, [m]</td><td>0,65</td><td colspan="2">0,75</td><td>0,45</td><td>0,35</td><td>0,60</td></tr>
<tr><td>G_p, [m]</td><td>0,65</td><td colspan="2">0,75</td><td>0,70</td><td>1,00</td><td>1,00</td></tr>
<tr><td>Anticipant - W, [m]</td><td>0,325</td><td colspan="2">0,375</td><td>0,225</td><td>0,175</td><td>0,30</td></tr>
<tr><td>Distance between holes on the line – a, [m]</td><td>0,45</td><td colspan="2">0,35</td><td>0,30</td><td>0,40</td><td>0,40</td></tr>
<tr><td>The vertical distance between rows – b, [m]</td><td>0,325</td><td colspan="2">0,375</td><td>0,225</td><td>0,175</td><td>0,30</td></tr>
<tr><td>Number of rows of holes - N</td><td>1</td><td colspan="2">1</td><td>1</td><td>1</td><td>1</td></tr>
<tr><td rowspan="4">Number of holes on a pole / beam – $N_{g, st}$</td><td rowspan="4">3</td><td>Ax A[2]</td><td>6</td><td rowspan="4">2</td><td rowspan="4">3</td><td rowspan="4">3</td></tr>
<tr><td>Ax B[3]</td><td>6</td></tr>
<tr><td>Ax B[4]</td><td>3</td></tr>
<tr><td>Ax C[5]</td><td>2</td></tr>
<tr><td>Length of hole – l_g, [m]</td><td>0,39</td><td colspan="2">0,45</td><td>0,53</td><td>0,75</td><td>0,75</td></tr>
<tr><td>Explosive charge per hole - Q_g, [kg]</td><td>0,100</td><td colspan="2">0,100</td><td>0,100</td><td>0,150</td><td>0,150</td></tr>
<tr><td>The number of discontinuous explosives loads - n_{ip}</td><td>1</td><td colspan="2">1</td><td>2</td><td>3</td><td>3</td></tr>
<tr><td rowspan="4">Explosive charge on a pole - Q_{st}, [kg]</td><td rowspan="4">0,300</td><td>Ax A[2]</td><td>0,60</td><td rowspan="4">0,200</td><td rowspan="4">0,450</td><td rowspan="4">0,450</td></tr>
<tr><td>Ax B[3]</td><td>0,60</td></tr>
<tr><td>Ax B[4]</td><td>0,30</td></tr>
<tr><td>Ax C[5]</td><td>0,20</td></tr>
</table>

Note: [1] The columns it situated at 2nd floor in the axis A;
[2] The columns it situated at the ground floor and 1st floor in the axis A;
[3] The columns it situated at the ground floor in the axis B;
[4] The columns it situated at 1st floor in the axis B;
[5] The columns it situated at the ground floor in the axis C;

6. Verification and interpretation of results

At this stage, are shown the collapse direction and the mode of the destruction of building (Fig. 9, 10, 11, 12).

In the terms direction of collapse and degree of destruction of the building following the collapse of the structure occurred as a result of controlled explosions, the simulation of the industrial building demolition meet the requirements to be implemented in practice.

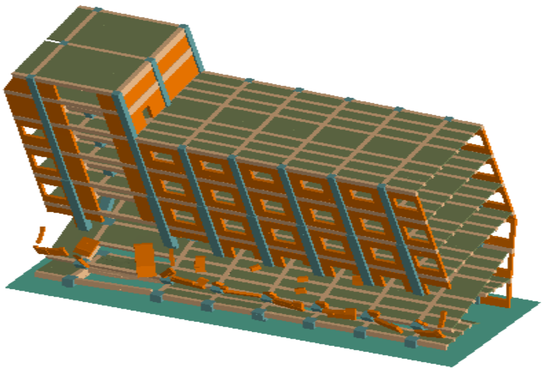


Fig. 9. The stability loss and start of the rollover

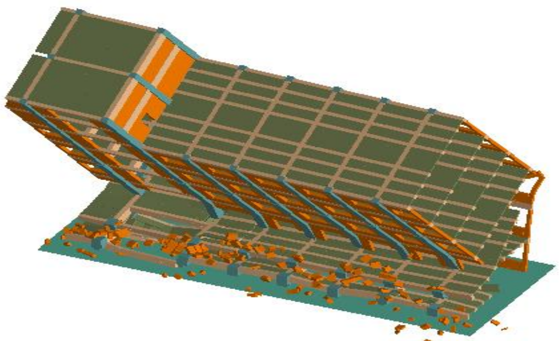


Fig. 10. The phase by falling of building

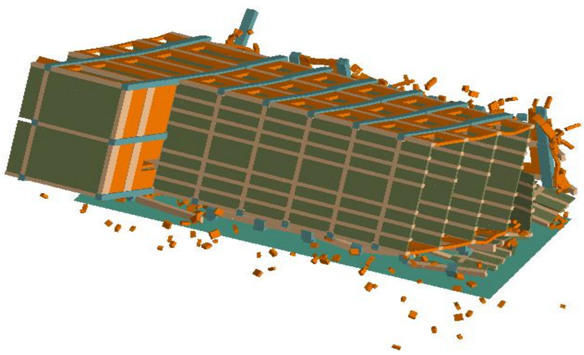


Fig. 11. The building collapse on the field

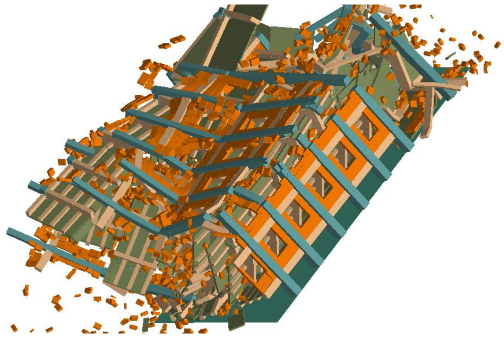


Fig. 12. The construction fragments after the its collapse

7. Conclusion

Simulation results validates the demolition scenario and the blasting parameters of the building (Table 1). This analyse can also constitute the basis for effective achieve of this demolition. The demolition analysis, showed that the structure collapsed in the desired direction and after impact with the ground was compact broken without it result the projections with long-range which to endanger nearby dwellings.

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Received: September 1, 2012 • **Accepted in final format**: October 4, 2012