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Autor: Baljkas, Boris / Zagar, Zvonimir

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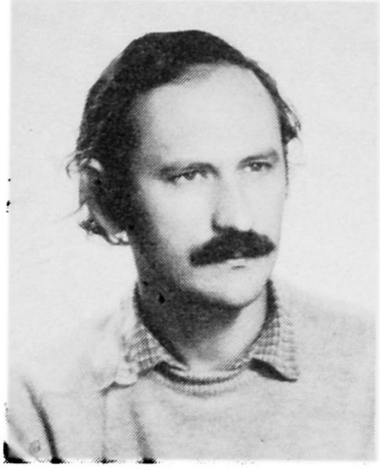
Structural Design of Blast Resisting Chambers

Calcul de chambres résistantes à l'explosion

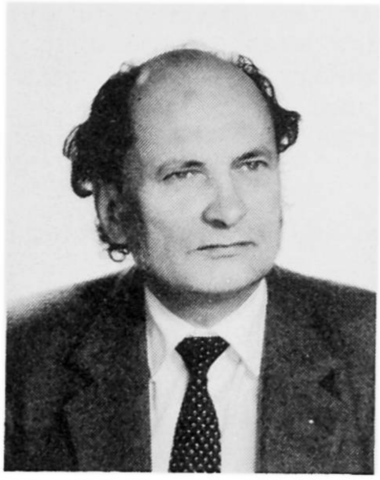
Bemessung einer Explosionskammer

Boris BALJKAS
Lecturer
University of Zagreb
Zagreb, Yugoslavia



Boris Baljkas, born 1949, graduated at the Civ. Eng. Fac. at the University of Zagreb. Since 1976 lecturer and since 1981 senior consultant at the Civil Eng. Fac. He has published a large number of scientific and professional papers from the field of computer design, static and dynamic analysis and theory of structures. Practical works includes design of r.c., steel, aluminium and wood structures.

Zvonimir ZAGAR
Professor
University of Zagreb
Zagreb, Yugoslavia



Zvonimir Zagar, born, 1931, graduated at the Civil Eng. Fac. in Zagreb. Professor at the Fac. of Arch., Kumasi University from 1965–1971, from 1971 to 1976, at the Interfaculty Transport and Traffic Study, Univ. of Zagreb. Since 1982 professor and Head of the Dept. for Wooden Struc. at the Civil Eng. Fac. Practical works includes design of r.c., steel, wood structures, ultra light and NU shelter structures. Published several books and large number (over 150) scientific papers.

SUMMARY
Structural design, static and dynamic analysis of a 'Protective Centre' is described. Special, in building, explosion-resistance chambers for explosion detection and initiation are designed. The results of dynamic analysis of a chamber due to a fixed explosive TNT charge is described in detail. The finite element method was applied using computer programs.

RÉSUMÉ
L'article explique les méthodes de calcul statique et dynamique d'une structure d'un centre de protection comportant des chambres de detection et de mise à feu de colis explosifs. Les résultats de l'analyse dynamique des chambres sont décrits en détail. La méthode des éléments finis ainsi que des programmes de calcul ont été appliqués.

ZUSAMMENFASSUNG
In diesem Artikel ist die statische und dynamische Berechnung von Explosionskammern für ein Schutzzentrum dargestellt. Im Gebäude sind spezielle Kammern für die Entdeckung und eventuelle Vernichtung von Explosivsendungen vorgesehen. Die Methode der finiten Elemente sowie Berechnungsprogramme wurden angewendet.

1. THE STRUCTURE

The 'Protective Center' is a 5-storey reinforced concrete building, consisting of three dimensional frame type of structure with slabs and shear-walls. Position of the shear-walls is determinated exclusively by functional reasons and less by some structural demands. In this way a very stiff system was created with relatively regular grids without greater differences in the positions of the center of stiffness and the center of mass. On the top floor there are very great masses in a joint block-the three rc chambers, for the control of eventual explosive packages. The chambers are covered with a protective vaulted structure with some openings in order to protect the surrounding population and neighboring buildings in the event of an explosion. Above the roof openings a suspesion chain net is fixed to protect the surrounding area. Some parts are disposable. The floors are rc slabs and beams where there are greater spans. The foundation is a rc slab, on a gravel layer.

2. STATIC AND DYNAMIC ANALYSIS OF STRUCTURE

2.1. The whole building

At the first step the whole structure was analysed as a 3D structure using the SD2A program. In the static and dynamic analysis all load-bearing structural elements were included in the mathematical model: columns, beams, girders, shear-walls, with certain restrictions of the calculation model. The masses are concentrated at the height of the floor slabs. The great masses of the Blast Resisting Chambers were included in the analysis.

The modal analysis method and response spectra analysis were applied to the dynamic analysis according to the YU Seismic Code. This was done using the SD2A computer program.

Maximum member and element forces are obtained for the influence of the earthquake applied in three independent directions, two in orthogonal directions and one in a direction at 45 degrees to the building axes, according to the estimate of the possible greatest effect of torsional mode. Special program for proportioning of rc members according to the ultimate strength method, were used on the PC SC328.

2.2. The foundation

The STRUDL program and TOPOLOGY subsystem, generator of data, were used for the analysis of the foundatin slab. Finite elements were used to simulate the slab on Winkler base. The elastic spring constants of the base are assumed according to the geomechanical report. The cellar walls and the cores were included in the FEM model.

3. ANALYSIS OF THE TNT EXPLOSION IN BLAST RESISTING (BR) CHAMBERS

The BR chambers and floor slabs on the third floor where a TNT blast could possibly take place have been analysed for both, static and dynamic loading as follows:

- the floor slab for uniform and ckeck distributed load,
- the floor slab for control static load 60 KN/mm,
- the floor slab, walls and roof core of the chamber for explosion impact load,
- the floor slab and walls for equivalent static load.

The postulated impact wave is shown in the Fig. 1. The values are obtained from (13) and factorized with the factor

$f = p \;\; / p * F$ where:

p – pressure at a distance of from the center of the explosion,
p – pressure at a distance of 1.5 meters from the center of the blast and comes to 400 KN/mm,
F – a surface that belongs to a specific node.

The same method was used for designing the vaulted roof structure and heavy moving parts (doors etc) as parts of the whole structure.

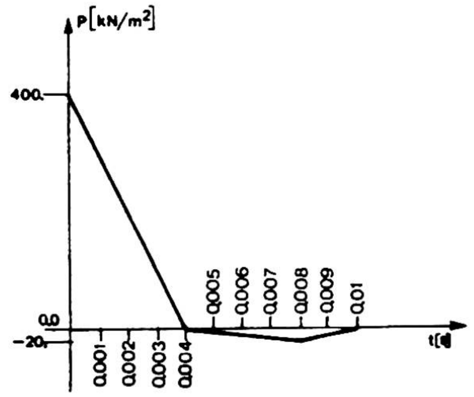


Fig. 1. Assumed impact wave explosion.

For the needs of dynamic analysis in real time the impact wave is described as 'Time History' in the data storage of the program STRUDL. It was obtainted in a separate research study.

From (1) and (6) we can conclude that analysis of the blast impulse effect on the entire system is conducted up to the substructures of the system. For this reason special consideration is given to the effect of shocks to possible walls, slabs and a sector frame of the whole building from the roof to foundation, with possible blasts in the inner and outer chambers. In this analysis the plate bending FE of the slabs and walls were used.

Independent of this, the whole system of the chamber, shown in Fig. 2, is modeled as the FE members model in order to provide a global insight into effect of a blast on the whole. The impact wave in this case is divided into three directional components (x, y, z) and placed to act at the crosspoints of members which represents the slabs and walls with corresponding stiffness.

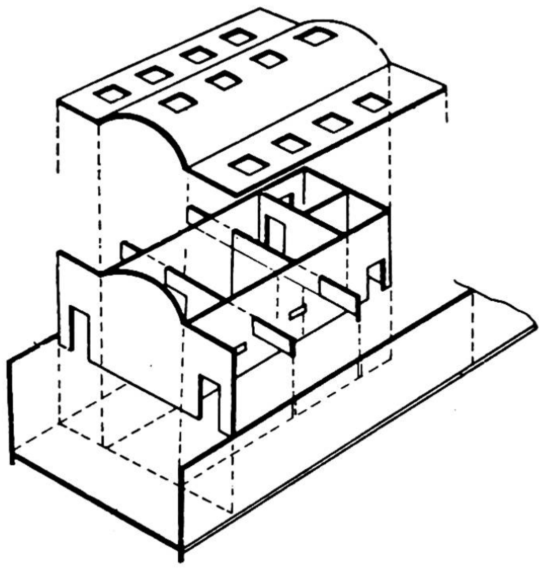


Fig. 2. The chambers divided into substructures.

Characteristic results obtained using dynamic modal analysis are shown in Fig. 3. The deformation time history of the point on the wall is visible during the time of the blast effect.

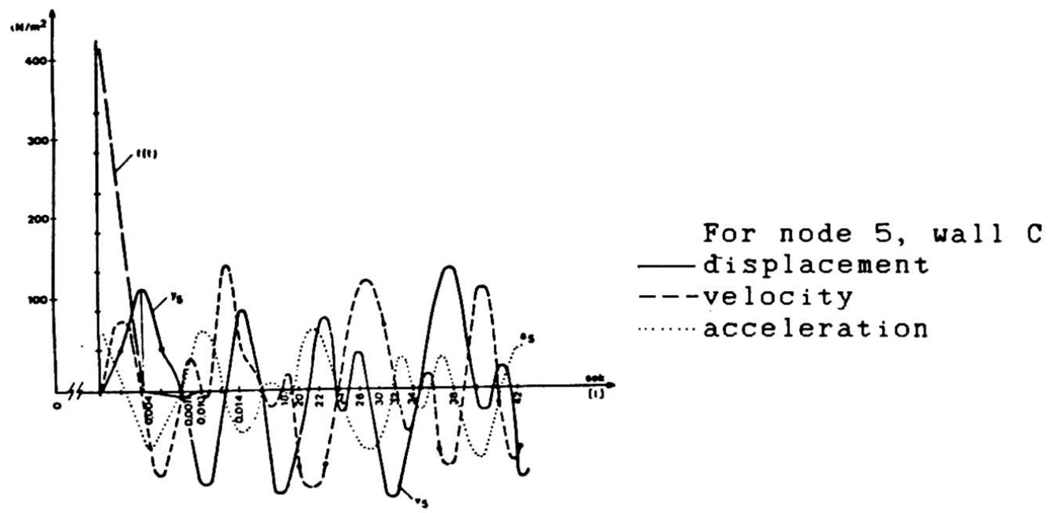


Fig. 3. Result of dynamic analysis. The finite element method and real-time response.

4. CONCLUSION

All these analyses have shown a relatively small effect of certain possible amounts of TNT explosive charge to the building and its structural elements. The cause of this is the large mass at the top of building that provides resistance to the dynamic shock wave. Dynamic shock of the blast is relatively great in intensity but very brief in duration. The forces that erupt in such a short interval are relativly small and it is not necessary practically to provide much additional reinforcement above the normal reinforcing, constructive reinforcments. Dynamic analysis of this type shows the lack of reality in today's analysis of NU shelters that do not take the sites into consideration, the speed with which the nuclear impact wave spreads and its intensity. An obligatory application of real-time dynamic analysis is proposed when designing explosion resistant or blast protective shelters because it can provide considerable savings in the amount of building material.

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