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NONLINEAR CALCULATION OF EXPLOSIVE LOADS ON BUILDING STRUCTURES OF SHELTERS

When designing buildings and structures, loads are collected in accordance with DBN B.1.2-2:2006 ‘Loads and Impacts’. Explosive loads in the seventh standard are classified as special types and their values are proposed to be determined by industry recommendations, namely DBN B.2.2-5-2023 ‘Civil Protection Facilities’. This standard defines the loading schemes for building structures when they are subjected to an airborne shock wave (ABW). The loading schemes defined in this document have some drawbacks. They stem from the fact that the blast load is considered as a result of detonation of a nuclear warhead, the radius of the blast front is much larger than the size of any structure, so this load acts on the entire structure simultaneously, and therefore it is considered as quasi-static with the use of dynamism coefficients that increase the calculated static load on the structure.

In current conditions, such an approach is not quite true: firstly, rocket and artillery charge explosions have a more local impact on the structure, and secondly (as a consequence of the first), there is an uneven, purely dynamic load on the structure which shouldn’t be less. In addition, the wavelength of the ABW from the condensed explosive creates a dynamic load, the duration of which is usually proportional to the fundamental frequency of the natural vibration of the structure ω, which is determined by the movement of the structure in the stage of elastic deformation:

$$\frac{d^2T}{dt^2} + \omega^2 \cdot T(t) = \omega^2 \cdot f(t) \qquad [1]$$

Thus, the dynamics of impact can be determined both by the resonance effects of structural vibration and by the movement of the ABW front along the surface of the structure.

In order to determine the initial data, when calculating the strength and stability of building structures by modern methods, it is necessary to know the dynamics of load changes in the time-coordinate system, which is set by tabular values or in the form of a load curve P = f(t). Such a calculation mode could be used, for example, in the ‘Lira’ software package. However, the existing analytical calculation methods allow solving only a stationary problem - to identify the load area from explosion.

To determine the dynamics of the explosive load, the task is to develop a methodology for calculating the spatial and temporal dependence of the excessive load change in the building structure at the moment of explosive blast on it.

The problem of calculating the dynamics of the explosive load on a building structure (e.g., the ceiling of a buried shelter) was solved by jointly solving the equation of the spatial distribution of overpressure in the front of the blast and the dependence of the blast time on the speed of its front movement, which can be expressed by equation. [2]

$$dt = \frac{l}{v}dv; \qquad (2) \qquad t = \int_{v_1}^{v_2} \frac{l}{v}dv. \qquad [3]$$

Since the velocity of the ABW is constantly changing, equation [2] has a differential form, and its solution [3] is based on the assumption that the simultaneous action of the ABW on the surface of the building structure occurs on the area limited by the length of the shock wave front. Based on this, a graphical-analytical methodology has been developed for determining the spatial and temporal dependence of the excessive load change in the building structure at the moment of explosive blast on it. This dependence is demonstrated as a table or graph, which is a loading curve.

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CONSTRUCTING GLASS SKYSCRAPERS IN THE FUTURE

Glass skyscrapers have become iconic symbols of modern cities around the world. However, there are ongoing discussions about their energy efficiency and environmental impact. Let's explore the topic further:

Energy Efficiency Challenges: Traditional glass exteriors in skyscrapers can be energy inefficient. They trap heat during summer and lose heat during winter, leading to increased reliance on air conditioning and climate control systems. This results in higher energy consumption and carbon emissions. [1]

Eco-Friendly Innovations: To address the energy efficiency challenges, new glass skyscrapers are incorporating eco-friendly innovations. These include renewable energy generation, solar shading systems, and double-skin facades that provide better insulation and reduce heat transfer. [1]

Mixed-Use Skyscrapers: Urbanization trends have led to the rise of mixed-use skyscrapers, particularly in countries like Japan and China. These buildings combine residential, commercial, and recreational spaces, promoting sustainable urban development and reducing the need for long commutes. [1]

Smart Technology Integration: Smart technology plays a crucial role in the construction of modern skyscrapers. Switchable smart glass, for example, allows users to alter the properties of the glass at the flick of a switch, providing flexibility in controlling light and heat transmission [2]. Additionally, advanced technologies like IoT sensors and prefabrication methods contribute to the transformation of high-rise buildings into smart and sustainable structures [2].

Environmental Concerns: There is a growing debate about the environmental impact of glass skyscrapers. Critics argue that the energy-intensive cooling requirements and the lack of consideration for location and urban planning can lead to poor design, increased carbon emissions, and a reliance on private cars [3] [4].

Sustainable Design Approaches: Architects and engineers are exploring alternative design approaches for glass skyscrapers. These approaches include reducing the proportion of glass in the facade, incorporating long-life materials, and considering the recyclability and maintenance of glass wall assemblies. [5] [6]

It's important to note that the future of glass skyscrapers will likely involve a balance between aesthetics, functionality, and sustainability. Architects, engineers, and urban planners are continuously working towards finding innovative solutions to make glass skyscrapers more energy-efficient and environmentally friendly.