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Mass-produced Structures of Multistorey Houses

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Summary

The design and structural solution of a multi-storey building system and superstructures using thin-walled three-dimensional steel units is an example of a structurally and technologically advanced type of designing structures for the future. Among its structural advantages there are e.g. a considerable ductility of the system and its resistance to seismic impacts. The load-bearing system of buildings is created by a composition and mutual interaction of three-dimensional steel units with contact bearings through horizontal bonding brackets. Superstructures designed for seismic or undermined regions are characterised by the concentration of the "mass" of the structure close to the core (centre) or by elastic connection of some parts of the bearing system, reducing thus the loading due to seismic effects, the effects caused by the differences in the building's settlement etc.

Keywords: mass-produced structures, thin-walled three-dimensional steel units, horizontal connecting brackets, superstructures, troubled geological and seismic regions, thin-walled gable profiles, loading tests, dynamic characteristics, extreme loading

1. Constructional and structural design of a multi-storey building system and superstructures from thin-walled three-dimensional steel units

According to the structural arrangement of three-dimensional units, a number of variable structural systems of multi-storey buildings or, in combination with other structures, the so called superstructures, may be designed. Horizontal bonding brackets act as bonding elements between individual three-dimensional units. They are "loosely" laid on the corner units' joints forming continuous "surfaces" for mounting upper three-dimensional units. Horizontal brackets stabilise the structure in the mounting horizontal plane, providing, at the same time, distance intervals between the units in both directions.

Supersystems with three-dimensional units are characterised by more distinct structural principles of a superstructure. In high-rise superstructures it is, as a rule, the effects of horizontal loads that have a decisive share in the concept of the loading structure design. Superstructures designed for seismic or undermined regions are characterised by the concentration of the "mass" of the structure close to the core (centre) or by elastic connection of some parts of the bearing system, reducing thus the loading due to seismic effects, the effects caused by the differences in the building's settlement etc.

The application of three-dimensional units within a supersystem allows for their wider and more variable usage. A superstructure creating "construction surfaces" for the multi-storey building unit as a whole, acts, at the same time, as a "compensation member" between the effects and impacts (force, deformation) of the outside environment and the purpose-built structure of three-dimensional units itself. This allows to design and manufacture unified building structures, implementing them in quite varied conditions, to erect buildings in troubled geological and seismic regions, in territories with extreme traffic requirements etc.

2. Load-bearing structure of a three-dimensional unit

The load-bearing structure of a three-dimensional unit consists of thin-walled steel profiles, cold formed into rectangular gables. In its transversal direction, a wall three-dimensional unit section is shaped as an enclosed plate frame with rigid joints. Corner joints are formed by mutual sliding of perpendicular gable profiles onto each other and by their subsequent connection by spot welds along the contact surfaces of profile walls. The vertical load-bearing structure of wall sections is formed by gable section profiles, similarly to the ceiling and floor structures.

Thin-walled gable profiles are mutually interconnected to form a three-dimensional load-bearing structure by spot welds on the production line, without using any other auxiliary or reinforcing profiles. After the thin-walled steel gable profiles have been welded to form a load-bearing structure on a production line, the structure is sprayed with protective anti-corrosion and fire-proof agents and it is gradually fitted with distribution frames and installations, insulation and facing slabs etc.

The sections' dimensions have been designed with regards to the functional and transport requirements (the sections' width being 2,400 mm to 2,700 mm, their depth 5,100 mm to 7,500 mm and their height 2,950 mm to 3,400 mm). The weight of a steel structure of a three-dimensional unit (section) with a net floor area of 14 m^2 is approximately 750 kg - 1050 kg, the weight of three-dimensional column unit approximately 550 kg - 810 kg, depending on used profiles.

The three-dimensional steel structure was exposed to a series of loading tests. The static and dynamic loading tests were aimed at the verification of theoretic computation estimates, the joint's functioning and comparison of theoretically computed and measured values. The test results show a very high level of compliance with theoretic computations. No failure of the structure occurred and not a single case of reaching the plastic deformation zone was recorded during the tests. The results of verification tests and structural computations proved the feasibility of application of three-dimensional steel units in the construction of 8- to 12-storey buildings. The analysis of dynamic behaviour of a multi-storey building composed of three-dimensional steel units has shown satisfactory characteristics of the load-bearing system.

The relative rigidity of elastic bearings at the joints between three-dimensional units, as compared with the relative rigidity of enclosed plate frames, makes it possible for the bearings to absorb a considerable part of deformational energy (seismic effects, gusts, shocks etc.) when subjected to dynamic impacts, reducing thus the stress and deformation of the three-dimensional steel units themselves, so that they do not exceed the elastic impact zone. In this way the failure and loss of mechanical resistance of the load-bearing structure due to effects of extreme loads may be prevented.

Experimental measurements on a testing site have shown excellent characteristics of the structure from the point of view of acoustic comfort and energy demands.