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Assessment of Structural Safety of Prefabricated Buildings

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Summary

In the course of time, the load-bearing system of multi-storey prefabricated buildings is exposed to loads with variable, alternating and cyclic components (temperature, moisture, wind, ground vibrations, dynamic traffic impacts, sound wave impacts etc.). In relation to the ratio of the permanent and alternating load components, the construction and reinforcement of bearing joints and bonds, degradation of structural properties of the joints and bonds occurs due to the impacts of variable unidirectional, as well as alternating loads resulting in lower structural safety of the load-bearing system and consequently in its decreased residual service life. Practical examples testify to the time factor impact on the degradation of the structural qualification of the load-bearing system. A reliable reconstruction design of prefabricated buildings has to be based on numerical assessment of the load-bearing system considering residual joint rigidity.

The properties of load-bearing structures are characterised by the so called load-bearing qualification which may be defined as the ability of a structure, or a load-bearing system to fulfil the required load-bearing functions from the point of view of ultimate bearing capacity and functionality under static and dynamic loads and other impacts causing mechanical states of stress or deformation and strain.

Load-bearing structures are exposed to: the impacts of vertical and horizontal loads, climatic load impacts (wind, snow, temperature, moisture), the impacts of changes in the footing bottom shape, dynamic traffic impacts, rheological impacts, as well as chemical, biological and other impacts.

During the service life of buildings, these impacts may be visibly displayed by the appearance of failures. In assessing failures it is necessary to distinguish between technological defects or failures which are often associated with prefabricated structures and structural failures caused by some of the above mentioned impacts. A major part of failures of prefabricated structures are those caused by temperature and moisture.

The intensity and character of the resulting loading effect change in relation to the intensity and ratio of individual loads in a given time. Apart from decisive vertical loading effects due to the weight of load-bearing and finishing structures which may be specified as constant, permanent, unidirectional loads with negligible dependence on time, load-bearing systems are exposed to short-term or variable impacts, both of unidirectional and alternating character. These are, above all, temperature, moisture, wind impacts, variable components of operable



loads, ground vibrations, dynamic traffic impacts, sound wave impacts etc. These impacts cause that individual parts of the structure are, in the course of time, exposed to loading with a variable, alternating and cyclic component. In relation to the ratio between the constant and alternating component, the construction and reinforcement of the joint, degradation of static properties of joints exposed to the impacts of variable loads may occur in time lowering the structural safety of the load-bearing system or affecting the service life of the load-bearing system.

The relevance of defects and failures discovered during a structural and technical investigation may be assessed on the basis of structural, as well as constructional and physical evaluation based on a truthful computational model of the structure, a computational model of loads and a material model of the structure. In this relation the properties of materials and structures have to be considered as variable quantities, depending on time and environment. Without the knowledge of their time-dependent behaviour, the problem of durability and reliability of load-bearing systems cannot be solved. The changes of properties in time are most frequently caused by variable unidirectional and alternating loads, corrosive and degradation processes (physical, chemical and biological impacts).

A reliable reconstruction design of a prefabricated building is based on numerical evaluation of the structural qualification of the load-bearing system considering the lowered rigidity of bearing units' joints, or the so called residual rigidity of joints suffering from mechanical failures during investigation. This procedure always has to be respected if failures caused by cyclic temperature and moisture impacts are in question. Corresponding structural modifications and rehabilitation of the damaged units and joints have to be assessed with regards to the history of loading to avoid repetitive occurrence of failures.

The aim of numerical analysis is to determine the so called critical points of the structure (load-bearing system) which are of vital importance to the structural safety and reliability of the system. Defects and failures occurring at these points belong mostly to the category of serious failures of the load-bearing structure requiring, as a rule, immediate and extraordinary measures (such as temporary structural support, structure lightening etc.).

Among serious defects and failures there are all defects and failures lowering, in a significant way, the ultimate bearing capacity and rigidity of the load-bearing system. A gradual development and propagation of failures (cracks, disintegration etc.) create redistribution of internal forces from damaged points to unaffected areas. If there are no reserves in the structure to compensate for the increased loads due to this type of redistribution, local or overall failure (collapse) of the structure (system) may occur. Among these serious failures there are prominent continuous cracks in vertical joints of walling units, cracks and ruptures at the joints between walling and floor units, prominent continuous cracks in longitudinal joints of floor units, impaired and insufficient ultimate bearing capacity of walling and floor units.

In safeguarding 3D rigidity of the load-bearing system and its resistance to the effects of extraordinary loads leading to breakdown condition of the building, principal importance is attributed namely to horizontal and vertical reinforcement installed in the units and interconnected at joints, or reinforcement placed in the units' joints, i.e. bracing and sealing reinforcement. Prefabricated structures with a non-existent or insufficient dimension and implementation of this reinforcement show a small range of elastoplastic and plastic deformations, they are liable to the appearance of failures and they are not sufficiently safe in relation to extraordinary loads of breakdown type.