Retrofitting of Residential Prefabricated Buildings in Hungary

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Summary

The specific structural model of Panel-System buildings is presented highlighting the importance of the inhomogeneities occurring between the different types of concrete like high strength cured panel bodies and in situ cast fresh fillings with partial local reinforcement. The elasticity and the deformation behaviour is significantly different in the panel bodies and in the joints. So the answer of the composite structure is very much different from the expected results gained from the common structural model of homogeneous (perforated) discs. This behaviour causes important stresses in some zones in the buildings with 10 or more storeys even in case of standard design wind speed. The realistic and necessary life span of about 100 years requires some extra load-bearing reserves also for extra impacts like fire, limited seismicity, etc. The large number of such houses underlines the necessity of clear knowledge of the real structural conditions.

Keywords: Panel-system buildings, inhomogeneity, joints, compatible deformations, shrinkage, horizontal loads, load-sharing, temperature-differences, load-bearing, life-span.

1. Description of the Panel-System Housing in Hungary

The centrally financed wide-range housing with panel-system was representative in Hungary between 1960 and 1980, like in many other Central-European countries. The peak production capacity exceeded 2 Million sqm flat area per year in approx 15 plants located in the major cities of Hungary. Such sudden growth of housing was not possible with traditional technologies. The panel-system housing also ensured the reduction of the required working capacities at the site and led to an overall reduction of the specific working hour demand per flat-sqm. These houses were installed with slightly higher standard than before but the durability of the furnishing elements was not sufficient. So partial modernisation is more and more required by the users. This demand even increases because of the change in social needs. At many houses there is a significant shortage in the thermal insulation parameters too, underlined by the recent rising energy prices. By now approximately 15% of the national stock of flats consists of panel-system houses. Since it is not possible to replace them within a short time the modernisation and the proper maintenance of these buildings has high importance. On the other hand there is practically no way to dismantle them economically taking into consideration the high energy demand and the problems of the disposal of resulting debris. So the only possible strategy should be the retrofitting and the planned operation for long life-span of these buildings. The long life-span causes higher pricing of the load-bearing components and the need of clear sight of the real structural behaviour.

2. Specific Structural Character of the Multi-Storey Panel-System Houses

The most important reasons which make unusual the structural behaviour of these houses come from the construction technology itself. The large size panel elements are prefabricated so they obviously must have rather high strength just for the needs of the early transportation and storage. Their controlled, „factory made" concrete with proper water/cement ratio and accurate compacting produces high quality and high deformation modulus. The dominant part of their shrinkage takes place before the erection of the house. Later at the site poorer and often over-watered, not properly compacted concrete is poured into the „3-D network" of the joints to connect the panels. This site work is difficult and the quality control has much worse chances. So the void ratio in the concrete of the joint can reach even 25 or 30%. Based on these conditions its shrinkage ratio is about 0.5 to 1.0 $^0/_{00}$, its elasticity modulus and ultimate stress is much less than those of the high strength concrete of the panels, and the creep effect also takes place even under small stresses. At the same time the rest of the shrinkage occurring in the panel after the erection is only about 0.1 $^0/_{00}$. The concrete of the joints starts its life only when the panels are already „matured and shrunk". So the cracks of shrinkage definitely develop in the concrete of the joints and at the contact surfaces with the panels just in the very first weeks of the life of the house. In this way the strong and rigid panels of good quality are connected to each other by rather weak and cracked, heavily shrunk joint-concrete zones. This situation forms really the definite conditions of the inhomogeneity. Unfortunately the researchers and designers who are not very familiar with the construction technology often neglect the site conditions causing serious inhomogeneities. The real proofing of all these aspects may come only by costly and complicated large scale tests and measurement series. Such tests in Hungary in 1980-81 proofed the behaviour being different from a homogeneous model. Here the improper level of joint working between the neighbouring wall elements was detected together with the high deformations of the vertical joints. Also was proofed the overloading and cracking of the trimming zones. It is important to mention that only about 60-70% of the loads/stresses come from the permanent/dead load at a 10 storey building. The rest is caused by alternating effects (winds, etc.). The really developed stresses/deformations in several zones can exceed the correct limit of reversible (elastic) deformations. The repeated effect of non fully elastic deformations seriously influences the life-span of the structure. The computation method with all of its details and practical simplifications was developed gradually within a longer time with a permanent interaction of site control. The rigid and high grade indeterminate composite structure has also an important side effect of extra loads caused by the temperature-differences between the elements of the facade and the internal ones. The panel building is rather sensitive to the differences of sedimentation as it was proofed by the model experiments too.

3. Behaviour of the Inhomogeneous Structure Derived by the Ultimate Deformation Mechanism of the Concrete

One of the most important problems of joint working occurs in the vertical joints. Here the „storey-high" (approx. 3 m long) beam of joint-body develops more than 1 mm of accumulated longitudinal shrinkage. Because of this the body of the joint is separated/broken into parts. When shear-type vertical connecting forces intend to develop between the panels to be connected - they can not be transmitted until a higher deformation of the panels will not close these cracks. These necessary higher deformations of the wall-panels develop at 10-storey (or higher) buildings by the usual vertical (structural + wind-caused) loads/stresses but the concrete of the joint has furthermore lower deformation modulus and ultimate strength which are both limiting the transmittable forces. Similar connection problems were proofed in horizontal joints by large scale laboratory tests between 1980 and 81 in Hungary.