Low-Rise Monolithic Steel-Reinforced Concrete Houses on the Basis of the "Load-Bearing Floor" Constructive System

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Abstract. The load-bearing floor is a box-shaped structure consisting of monolithic floor slabs cohesive with all walls and partitions located between them [1]. The load of the bearing floor is transmitted only to the exterior walls. Thereby, the spaces within the outer walls located under the bearing floor and above it don’t require any intermediate support. The effectiveness of the load-bearing floor construction implementation is the ability to obtain freedom while making planning decisions, re-planning in the process of the operation and reducing the consumption of structural materials for creation of the building carcass compared to the existing traditional structures [2]. In [3] authors describe the technology of construction of the bearing floor and present the results of computational studies of the stress state of its elements in their different design. In this article we discuss the planning and design features of the load-bearing floor in steel-reinforced concrete structures of low-rise buildings.

1. Introduction

Nowadays constructive solutions of buildings with a free layout, which allows changing the interior space of the floors throughout the entire service life, are becoming more and more in demand. Such solutions are investigated in works [4-8].

There are two factors which make an impulse for creation of new construction systems for house building. The first factor is that in Russia there has been set a task to achieve the same level as the developed countries have that provides a living minimum of 30 m² of total area per person throughout the lifetime of one generation. This circumstance leads to the need of building housing with large spaces, i.e. apartments and private houses as well as small premises should include rooms larger than 20 ÷ 30 m³. Consequently, a significant part of mass capital housing currently being built with small size rooms, and it won’t meet the living standards of the next generation.

The second factor is that under the new economic conditions the mobility of the population has increased, and consequently the rapid change in demography both in cities and in individual houses appeared. This required the creation of houses with the possibility of free planning at the initial stage of their operation, and the possibility of future re-planning according to the time requirements.
Modern constructive systems, based on the classical post-and-beam structure, have the carcasses of buildings which are not subject to reconstruction in order to increase the spans to further large room creation. Thus the problem of increasing the span of floor structures to expand the area of the premises, providing freedom of planning and re-planning, becomes urgent. Such a problem can be successfully solved by using a constructive system of the load-bearing floor.

The idea of creating a load-bearing floor is based on two aspects: humanitarian and technical. The humanitarian aspect is that any dwelling combines large and small rooms. Small rooms are usually designed for a stay of one or two people. These are bedrooms, lavatories, offices, storage rooms for clothes, apartment equipment and other things, corridors. They form a bearing floor overlapping the free floor, in which large premises such as dining rooms, living rooms, sports, professional and amateur workshops are located. Under these conditions the task of the architect is to create a comfortable space-planning composition (Figure 1).

![Figure 1. The building model created on the basis of the "Load-bearing floor" constructive system (the front walls are conventionally not shown).](image)

The technical aspect is the rational distribution of building materials in the construction of the load-bearing, providing their strength and acoustic properties.

The application area of the load-bearing floor in low-rise constructions is very wide: private buildings (cottages), blocked residential buildings (duplexes, townhouses, etc.), apartment buildings (sectional, corridor, gallery).

It is convenient to form the bearing floor in monolithic reinforced concrete houses, which include rigid reinforcement. In modern terminology, such constructions are called ‘steel-reinforced concrete’ (p.3.4., [9]).

Rolling fittings in the form of channels are laid in places where walls are supported on foundations and on the spots where walls are joined to floors. They also may be used in the form of racks in the inner layers of three-layer external walls for giving them stability during concreting and operation. Thus the fringing slabs channel bars welded with vertical channel bars form a ‘basket’, fastening the building in a rigid box, providing it with a steady convergence. It is convenient to weld reinforcement partitions to the bordering channels at their primary manufacture and subsequent re-planning (Figure 2).
Figure 2. Fastening details of reinforcing bars to bordering channels.

It is also convenient to weld reinforcement of such facade elements as balconies, loggias and bay windows. Rolled reinforcement in the form of a corner fringes door and window openings and removes the tension concentration of concrete in the corners of the openings. Rods of reinforcing grids (working background and structural reinforcement of class B500) and working design reinforcement of class A500C or A400 are welded to rigid reinforcement, thereby ensuring its reliable anchoring. This concept is shown schematically in Figure 3.
The simplest and giving the largest yield of free space is the bearing floor with one partition in the middle (Figure 4). In this case, two half areas of the bearing floor are added to the free area under the carrying floor.

At the same time, a comparison of the consumption of concrete into two continuous slabs in a two-story house with a plan size of 10.0 x 10.0 m with a consumption of concrete on the bearing floor gave the following results. With a free (without intermediate supports) area of two floors, the consumption of reinforced concrete (concrete) for two floor slabs with a thickness of 0.3 m will be 60 m$^3$. When designing the load-bearing floor, two slabs with a thickness of 0.15 m each (continuous slab with a
span of 5 m) consume 30 m³ and 2.4 m³ per partition 10x3x0.08 m. Using the load-bearing floor construction the concrete consumption is reduced by 27.6 m³ compared to the consumption of traditional solid slabs. At the same time, the height of the premises increased by 0.15 meters while maintaining the height of the floor.

If there occurs a need for overlaps made in the traditional way (to put the same (or other) partitions), there will also be a need to spend extra finances on additional materials. Adding partitions to the bearing floor with any particular planning solution will further reduce the thickness of the floor slabs, since their spans between the partitions will become smaller. Reducing the consumption of concrete, in this case, depending on the planning decision, can be 2-3 compared to traditional plates.

Of course the considered variation of planning decisions is possible at the design stage, where it is necessary to pre-set the invariable future thicknesses of floor slabs. And here many possibilities and limitations appear for both the project designer and the customer. The possibilities lie in the fact that during operation the planning solution of the bearing floor can be changed by introducing new partitions according to the technology described in [3] and removing existing ones. As to the limitations, there are two types of them: structural and acoustic. Structural limitations are lying in the permissible values of the spans at the thickness of the floor slabs specified during the initial construction. In any case, the ratio of the spans of the plates to their thickness should be at least 30, and their thickness should not be less than 10 cm.

Acoustic limitation is the need to comply with the rules for acoustic insulation. According to (section 9.2., [10]), interroom apartment walls and ceilings should have an airborne sound insulation of 50-54 dB. This insulation is provided by concrete thicknesses within 16-25 cm. Interior floors and walls without doors should have sound insulation 10 dB less, and it is provided by a layer of concrete 8-10 cm thick. Sound insulation of walls with doors is not standardized. Therefore, their thickness can be 4-8 cm. Private residential houses (cottages) designed for one family, are not encumbered by the norms of sound insulation for interroom partitions. This circumstance gives the project designer the opportunity to vary the planning decisions and the associated thicknesses of floor slabs and partitions, finding the optimal solution.

There is another possibility to vary the planning decisions and apply the partition walls corresponding to their sound insulation. You can initially apply the simplest solution described in the beginning of the article, and a floor thickness sufficient to cover the free width of the span (0.15 m in the considered example), and perform all other partitions in accordance with the sound insulation requirements using well-known gypsum cardboard sheets or tongue-and-groove plates. Such a solution is advisable to apply primarily in apartment-type houses, where the process of rearranging partitions should not affect apartments on adjacent floors.

Thus the structural system of the load-bearing floor opens up the possibility of creating new, time-demanded, space-planning solutions for houses with significant savings in construction materials for their erection.

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