Study of Composite Beam For Floor Structure of Solid Work

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Abstract - This work was commissioned by the specialized in steel construction. The work should be of interest to Rukki, any customer, design engineers and other construction companies dealing with civil engineering especially residential building. Data for this study were collected by building codes, books of construction disciplines and Rukki specifications and reports.The first part of the thesis contains general guidance, requirements and restrictions for the floor system in a residential building that takes place in Building Codes. The second part includes calculation points. It contains load estimation, I stage steel beam design and II stage composite beam design. The last part is a comparison of the results obtained by the created program with experience and computer-aided calculation accomplished by means of Solid Works. As a result of this project, the guidance for a designer with calculation algorithm of steel and concrete composite beam was made as soon as the program of the composite beam calculation was made in Microsoft Excel Software.

Keywords: composite beam, design of composite structures, calculations, program, Microsoft Excel Software, computer-aided Design.

I. INTRODUCTION

The purpose of the project is to design a steel-concrete composite beam with light weight concrete as a part of a composite floor structure that is more efficient than a common reinforced concrete floor structure with heavy-weight concrete. Application of light-weight concrete reduces permanent load acting on the floor and the frame of the building [1]. As a result of the work, an algorithm of the composite beam calculation was created in compliance with the requirements and limitations from Building Codes and also the calculation program was made in Microsoft Excel Software. It is simple in use with a small instruction. The program provides a design of the composite beam. As it was told earlier, the composite flooring system has been designed at first for nonresidential building [4].

A widespread composite flooring system is a concrete slab resting upon down stand steel I-beams. Collaboration of steel and concrete parts of the structure is provided by anchors welded on the upper flange of the I-beam. In order to apply a composite flooring structure in residential building it is important to minimize the thickness of the floor for effective space usage. Therefore the designed floor structure was developed to provide a minimum depth [3]. A down stand beam is replaced by partially encased into a concrete slab steel beam. Along the letter notation axis the flooring system is presented by a continuous monolithic ribbed slab [2]. It is poured by means of retained formwork as steel profiled sheet [5].

As a reinforcement of the slab bar mat reinforcement and reinforcing mesh are used. In another direction it is a steel-concrete composite beam with I-section. The steel beams are partially encased in the slab that eliminates the fire protection costs and 5 improve the flexibility of layout[6]. The usage of light-weight concrete and T-section of steel beam leads to reducing the overall dead weight. The flooring system that is designed will be applied in the residential 11-storey building. The total height of the building is about 33 m. The frame system is one of the modern mixed systems called Column-slab with rigid core [2].

II. MATERIALS AND METHODS

The fire class of a building should be known in order to define the required fire class for its load-bearing structures. In this case we are taking the residential 11-storey building. The fire class of the building is P1 defined by National Building Code of Finland E1, fire load is less than 600 MJ/m 2. In according to National Building Code required fire class for load-bearing structures is R120 that means the load-bearing structure carries 120 minutes under the fire.

Building code requirements for floor system of residential building

Static analysis is accomplished based on Structural mechanics. The main task is to determine the maximum values of shear force and bending moment in the composite beam. A scheme for static calculation is a beam with the span of 4m and uniformly distributed load. Static calculation was done by means of SCAD Soft. The maximum value of bending moment and shear force. In further calculations it is only maximum values of bending moment and shear force that are necessary. Therefore the values are determined automatically in MS Excel program.

Table 1 Material parameters

No.	Material	Thermal conductivity	Thermal capacity	Class of inflammability
1	Magnesite plate	0,216	750	KM0
2	Conlit 150 (Rockwool)	0,05	1090	KM1
3	Air*	0,16	1000	-
4	Concrete D1200	0,31	840	KM0

*- thermal conductivity of air is taken greater as correction due to convection.

Table 2. Specification of the flooring structure

No	Name	Vertical size	Function of the layer
1	Floor covering	7,5 mm	Cover
2	Cap	30 mm	Slab protection, leveling
3	Concrete slab	220 mm	Load-bearing and envelope
4	Steel profiled sheet	153 mm	Load-bearing and formwork
5	Conlit 150 (Rockwool)	20 mm	Beam fire protection
6	Magnesite plates	12,5 mm	Floor fire resistance
7	Steel fasteners (cold-formed members)	-	Fastening, air layer – floor fire resistant component.

III. OBSERVATION AND RESULT

The calculation is complicated by two stages: construction and operation. On the first stage the steel beam is calculated in compliance with SP 16.13330.2011 and SP 20.13330.2011. On the second stage the steel and concrete composite beam is calculated in compliance with SNiP 52-01-2003, SP 63.13330.2012, Code 1994. The total deflection of the composite beam is a sum of the steel beam of the I stage and the composite beam of the II stage deflections. The total state of stress is also formed by construction and operation stage stresses.

There are no district requirements for supporting the beam during casting. Steel beam is designed in such a way as a real deflection of the steel beam is less than limit deflection, I stage load is taken. But this implementation is appropriate only for the composite beam as the part of steel-concrete composite flooring system. Usually steel studs are used as an additional supporting of steel sheet.

In order to realize the benefits of the composite structures at the maximum level there should be a strong and stiff joint between steel and concrete structures. The joint is provided by steel anchors. The brace is steel bars that are placed along the beam by essential step. The bracing is necessary in order to ensure integrity of the structure.

The work does not consider reinforcement of design part of slab in calculation by means of Solid works as it serves mainly for spreading stresses along the concrete mass and avoiding stress concentration in the middle of the composite beam. The upper reinforcement contributes a little part of capacity in comparison with concrete mass. The reduction strongly simplifies grid creation process and reduces the total time of calculation.

IV. CONCLUSION

The calculation is complicated by two stages, construction and operation. On the first stage the steel beam is designed. On the second stage the steel and concrete composite beam is calculated. The total deflection of the composite beam is a sum of the steel beam of I stage and the composite beam of the II stage deflections. The total state of stress is also formed by construction and operation stage stresses. The most critical thing, in my opinion, was to provide enough strong and stiff connection between steel beam and concrete slab. The weakest point is an interaction of anchor and foamed concrete. It was particularly checked on local crumbling of the concrete. The easier but more expensive technical decision is to apply I-beam instead of T-beam that provides guaranteed strength of the composite beam. The created calculation algorithm was calibrated and confirmed by the computer-aided model analysis.

Comparison of the created algorithm with computer-aided calculation is based on the parameters such as deflection, compression stress, crumbling stress and shear stress. Finally, it should be noticed that Russian building codes need to be modified in compliance with contemporary construction. Building Codes have to be convenient for designers. The created composite beam calculation program is an example of improving work-conditions for the designers.

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