**УДК 624.073**

# STRESS-STRAIN STATE OF COMPOSITE STEELCRETE BEAMS AT THE ASSEMBLY STAGE

**Mykola Frolov,** PhD Stud**., Anastasia Myslytska,** PhD Stud**.**
*State Higher Education Institution*
*"Prydniprovska State Academy of Civil Engineering and Architecture"*

***Problem statement.*** Nowadays constructions with using composite sections (concrete floors on a steel beams, for example) is a popular in building industry. Using the anchors, cross-section ensures interoperability and more efficient in terms of bearing capacity than a similar non-combined cross-sections made by same materials. Currently, many methods of calculating the composite cross-section have been developed, and conditions of stress-strain state were taken into account. This is led to very close to real results, with a minimum of errors. However, almost nothing is known about the effects that occur at the assembly stage, when the composite section of steel and concrete is not yet joined, the concrete has not yet hardened and has not gained its strength. For example, in such cases, during the hardening of the concrete mixture, the reverse bending of the beam was observed [1].

***Purpose of the study*** is to investigate the redistribution of forces and the change in deflections during the stabilization of the concrete flange in the composite section.

***Main results.*** A 19.5 m long steel beam with a cross section area 270.4 cm (wall height 1 400 mm, thickness 12 mm, flange width 320 mm, flange thickness 16 mm) and a Young modulus equal to E = 206 000 MPa were accepted for this study. A concrete flange with a thickness 0.225 m and a width 7.7 m, with a Young's modulus from 10 MPa (non-zero, insignificant value that will not lead to mathematical or software error in calculations with zero value) to 30,000 MPa (design value for reinforced concrete class C20 / 25), were accepted to simulate hardening of concrete mix. The strength of concrete varied from 0 to 17 MPa, in proportion to the changes in the Young's modulus. The finite element model was made in the PC "ANSYS", the load has been set as the own weight plus the weight of workers with the tool, whole load was 7.33 kN / m$^2$. The initial small step of Young's modulus was chosen, in order to detect the moment when the concrete flange and steel beam will combine into a composite section. An additional model was prepared, using not a solid concrete shelf, but prefabricated reinforced concrete multi-hollow slabs. The values of deflections and normal stresses were measured (according to Kondratyuk E.V. [2], during installation there are various effects of stress redistribution, the nature of which is still not precisely determined, which many confirms in foreign sources [3] by accepted coefficients). Measurements were made in the upper flange of the beam support section, the lower flange of the beam support section, and the lower flange in the middle of the beam span section, as the most stress points, when the Young's modulus of the concrete flange was 10, 50, 100, 500, 1 000, 5 000, 10 000, 15 000, 20 000, 25 000, and 30 000 MPa. All data have been entered in the table below.

The results shows a decrease deflections of the beam with a monolith reinforced concrete flange from 1.416 cm at 10 MPa of Young's modulus to 0.387 cm at 30,000 MPa of Young's modulus, with a rapid changes in values up to 1000 MPa, and slow changes after 5 000 MPa. The values of normal stresses in the upper flange of the beam support section were changed from 264.81 MPa to 11.795 MPa, in the lower flange of the beam support section were changed from 245.46 to 123.74 MPa, and in the lower flange in the center of the span were changed from 74,479 MPa to 31.662 MPa. For the beam with a slabs flange, the values of deflections were 0.725 cm at 10 MPa, and decreased to 0.576 cm at 30,000 MPa. The normal stresses in the upper flange of the beam support section decreased from 107.46 MPa to 65.348 MPa, in the lower flange from 131.49 MPa to 111.3 MPa, and in the center of the span in the lower flange values were changed from 55.876 MPa to 47.273. Was also founded, when the Young's modulus increases to 1000 MPa, the values almost do not change, when increased to 5 000 MPa, are large changes in the values is occurs, and then stabilize again.

*Table*

| Model | Young's modu-lus, MPa | % max *E*, MPa | Deflec-tion, cm | Normal stresses, MPa | | |
|---|---|---|---|---|---|---|
| | | | | Support section upper flange | Support section lower flange | Center of the span lower flange |
| Monolith | 10 | 0,033 | 1.416 | 264.81 | 245.46 | 74.479 |
| | 50 | 0,167 | 1.325 | 251.62 | 242.31 | 73.553 |
| | 100 | 0,333 | 1.31 | 246.66 | 239.15 | 72.239 |
| | 500 | 1,667 | 1.165 | 198.46 | 223.81 | 66.555 |
| | 1 000 | 3,333 | 1.066 | 167.27 | 218.03 | 62.038 |
| | 5 000 | 16,67 | 0.72 | 68.496 | 184.05 | 48.562 |
| | 10 000 | 33,33 | 0.581 | 42.173 | 162.89 | 42.117 |
| | 15 000 | 50 | 0.506 | 28.403 | 148.88 | 38.145 |
| | 20 000 | 66,66 | 0.457 | 21.342 | 137.65 | 35.173 |
| | 25 000 | 83,33 | 0.422 | 16.758 | 130.12 | 33.439 |
| | 30 000 | 100 | 0.387 | 11.795 | 123.74 | 31.622 |
| Slabs | 10 | 0,033 | 0.7246 | 107.46 | 131.46 | 55.876 |
| | 50 | 0,167 | 0.7242 | 106.23 | 129.82 | 55.983 |
| | 100 | 0,333 | 0.7266 | 105.66 | 128.46 | 56.276 |
| | 500 | 1,667 | 0.7224 | 101.77 | 133.39 | 56.374 |
| | 1 000 | 3,333 | 0.7178 | 99.017 | 129.47 | 56.111 |
| | 5 000 | 16,67 | 0.686 | 88.354 | 123.91 | 53.917 |
| | 1 0000 | 33,33 | 0.659 | 80.965 | 120.33 | 51.889 |
| | 15 000 | 50 | 0.636 | 76.181 | 117.55 | 50.364 |
| | 20 000 | 66,66 | 0.617 | 71.978 | 115.26 | 49.141 |
| | 25 000 | 83,33 | 0.594 | 68.663 | 113.372 | 48.207 |
| | 30 000 | 100 | 0.576 | 65.348 | 111.49 | 47.273 |

***Conclusion.*** Based on the research, we can say that the largest changes between the values of deflections and stresses occur in the concrete flange between 1 000 and 5 000 MPa of the Young's modulus. These experiments also showed that the using the slabs as a fixed formwork is more appropriate for composite cross-section of the beam than a monolith floor on a profiled sheeting. It is especially important in cases where it is impossible to install inventory pillar, or the duration of installation is too long.

## References

1. Zamaliev F.C. Stress-strain state of a steel-reinforced concrete structure at the construction stage. *KazSABU News*. Kaz. : KazSABU, 2011, no. 1.

2. Kondratyuk E.V. Features of design and calculation of steel-reinforced concrete beams with free support of slabs. *Coll. of scient. works*. Kyiv : UkrNDPISK named V.M. Szymanowski, 2013, no. 11.

3. Jhonson R.P. Composite Structures of Steel and Concrete. *Beams, slabs, columns, and frames for buildings*. Blackwell Publishing, 2004, 230 p.