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Semko P.O., PhD
ORCID 0000-0002-5915-3082, e-mail syomka7@gmail.com
Skliarenko S.O., PhD
ORCID 0000-0002-3929-4240, e-mail poltpro@gmail.com
Semko V.O., DSc
ORCID 0000-0003-2438-0135, e-mail semko.vladimir@gmail.com
Poltava National Technical Yuri Kondratyuk University

DISMOUNTABLE JOINTS OF CONCRETE FILLED TUBULAR ELEMENTS

Abstract. *The stress-strain state and the bearing capacity of the dismountable joints of concrete filled tubular elements are investigated. The methods of calculation and constructive solutions of concrete filled tubular elements with joints are analyzed. Five new types of dismountable joints are proposed. Experimental studies of concrete filled tubular elements have been carried out. It was determined that the most effective for compression was a joint with a steel coupling and for bending the most effective was a joint with longitudinal ribs. The numerical modeling algorithm is presented; results are verified using experimental tests. A method for constructing N-M boundary dependences for concrete filled tubular structures is proposed. Bearing capacity diagrams for concrete filled tubular elements and their joints have been constructed. The costs of the materials needed to perform the joint as the example of a real construction for similar loads are analyzed.*

Keywords: *bearing capacity, concrete filled tubular elements, dismountable joints, numerical modeling, stress-strain state.*

Семко П.О., к.т.н.
ORCID 0000-0002-5915-3082, e-mail syomka7@gmail.com
Скляренко С.О., к.т.н.
ORCID 0000-0002-3929-4240 e-mail poltpro@gmail.com
Семко В.О., д.т.н.
ORCID 0000-0003-2438-0135, e-mail semko.vladimir@gmail.com
Полтавський національний технічний університет імені Юрія Кондратюка

РОЗ'ЄМНІ СТИКИ ТРУБОБЕТОННИХ ЕЛЕМЕНТІВ

Анотація. *Досліджено напружено-деформований стан та несучу здатність роз'ємних стиків трубобетонних елементів. Проаналізовані методи розрахунку та конструктивні рішення трубобетонних елементів зі стиками. Запропоновано п'ять нових типів роз'ємних стиків. Проведено експериментальні дослідження найбільш перспективних варіантів роз'ємних стиків трубобетонних елементів. Встановлено, що найбільш ефективним на стиск виявився стик із сталевою муфтою, при випробуваннях на згин найбільш ефективним був стик із поздовжніми ребрами. Представлено алгоритм чисельного моделювання; результати якого підтверджені за допомогою експериментальних випробувань. Запропоновано метод побудови граничних залежностей N-M для трубобетонних конструкцій. Побудовано діаграми несучої здатності для трубобетонних елементів та їх стиків. Проведений техніко-економічний аналіз роз'ємних стиків на прикладі реальної споруди торгово-розважального центру.*

Ключові слова: *напружено-деформований стан, несуча здатність, трубобетонні елементи, роз'ємні стики, чисельне моделювання.*

Concrete filled tube today is one of the most effective composite materials used in construction. Concrete filled tubular constructions are especially relevant as compressed elements of structures, in particular columns, and are widely used throughout the world. However, the most important and difficult task for the design of concrete filled tubular structures is the performing of joints. It is recommended to arrange them in the zone of zero

moments and the main load that they perceive is compression. However, often, especially during mounting, large bending moments occur in the joints. Therefore, the definition of tensile forces in the elements of the joints from the effect of external loads is a key issue, which the answer this work gives.

It should also be noted that the use of dismountable joints has a number of significant advantages over their integral analogues. In particular, the installation of the structure accelerates and a number of tasks connected with the dismantling of the building are solved.

The paper is devoted to solving the actual scientific and technical problem of determining the bearing capacity and describing the stress-strain state of concrete-filled tubular element dismountable joints on the basis of experimental, numerical and theoretical studies

The important scientific task of studying the stress-strain state and the bearing capacity of dismountable joints of concrete filled tubular elements is solved in the paper. The studies carried out in the work give grounds for making such conclusions:

Five new types of dismountable joints of concrete filled tubular elements have been proposed and investigated, namely: the dismountable joint of concrete filled tubular elements with a centering plate, the joint with hidden bolts, the joint with steel inserts, the joint with longitudinal ribs, the joint with a steel coupling and appropriate patents for utility models have been obtained.

It has been determined that in the case of experimental tests of samples on central and nonaxial compression, the most effective structure of the joint (which had the highest bearing capacity) was the joint which was made using the steel coupling with bearing capacity of 10-13% higher than other samples. In the study of samples with dismountable joints in bending and with eccentricities of more than 0.5D it was determined that samples with longitudinal ribs are the most effective ones which had more than twice the higher bearing capacity compared with the samples with steel couplings and flange connections.

With a purpose to the possible replacement of a part of the experimental tests by numerical studies in this work a detailed step-by-step algorithm for numerical simulation of a CFT element with a dismountable joint is presented. The size of finite elements (FEs) and their influence on the simulation results were analyzed. The following CE dimensions were taken into account: 15 mm for concrete and steel and 3 mm for bolts. Comparison of stresses in the compressed and stretched zone of the CFT element showed that numerical simulation has a high accuracy, the mean square deviation and the coefficient of variation of the data obtained fluctuated within the range of 5-8%, which is permissible and indicates that the modeling results correspond to the experimental data.

The non-iterative method of constructing boundary dependences of N-M concrete-filled tubular constructions is presented for the boundary state after reaching the boundary of the pipe-shell flow. Comparison of the results obtained with this technique, with experimental data showed a stock up to 17% for central compression and 2-4% for bending. The program is constructed and implemented in the form of an algorithm for constructing a diagram of the bearing capacity of the CFT section, taking into account the compressed part of the concrete core which made it possible to determine the tensile forces perceived by the elements of the joint. N-M diagrams of bearing capacity for concrete filled tubular elements and their joints (flanged, with longitudinal ribs and steel couplings) are constructed.

The most rational (with conditions of bearing capacity and material consumption) design of a dismountable joint is proposed, based on the calculation results for the building of a shopping and entertainment center in Kremenchuk. It turned out to be a dismountable butt of concrete filled tubular elements with longitudinal ribs, the steel costs were 13% less than for the coupling joint and by 54% - than for the flange joint with the same bearing capacity.

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