

THE CHARACTER OF CRACKING IN THE BEAMS WITH LOOP JOINTS

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Abstract. In connection with rather wide distribution of prefabricated-monolithic reinforced concrete in Ukraine, there was a need to increase areas of using various joints, in particular joints of reinforcement without welding. The loop joint (Perederiya joint) represents the releases of the armature from the ends of the elements in the form of concentric loops forming rings. The concrete in the space between the rings works on a comprehensive compression. Laboratory studies in this direction made it possible to add a certain picture of the cracking of test specimens with loop joints. The majority of researchers noted the intensive formation and development of cracks along the contour of contact between old and new concretes in the zone of the loop joints under various loads. And most of the existing recommendations are aimed at reducing cracking in such zones. In view of poor knowledge of the issue, it was decided to test the crack resistance of the splined loop joint in comparison with the keyless. The nature of the formation and development of cracks were established. Cracks are concentrated in the middle of the span in the place of the loop joint. In general, normal cracks were observed, but horizontal cracks also occurred. Cracking in samples with loop joints began with the appearance of hair cracks in the stretched zone in the middle part of the span and at the border of beams and joints concrete. Due to the jagged form of the keyed joint, the development of a crack along the border of old and new concrete in such joints was delayed at the tops of the «teeth».

Keywords: loop joint, cracking, pure bending.

ХАРАКТЕР ТРЕЩИНООБРАЗОВАНИЯ В БАЛКАХ С ПЕТЛЕВЫМИ СТЫКАМИ

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Аннотация. Проведен анализ трещинообразования в балках с петлевыми стыками, расположенными в зоне чистого изгиба, при шпоночном и бесшпоночном исполнении торцов стыкуемых элементов. В результате установлен характер образования и развития трещин, область распространения которых сосредоточена в середине пролета в месте устройства петлевого стыка балок. В основном наблюдались нормальные трещины, но при этом имело место образование горизонтальных трещин. Трещинообразование в образцах с петлевыми стыками начиналось с появления волосяных трещин в растянутой зоне в средней части пролета и на границе бетона балок и бетона стыка.

Ключевые слова: петлевой стык, стык передерия, трещинообразование, чистый изгиб.

ХАРАКТЕР ТРІЩИНОУТВОРЕННЯ В БАЛКАХ
З ПЕТЛЬОВИМИ СТИКАМИ

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Анотація. Проведено аналіз тріщиноутворення в балках з петльовими стиками, що розташовані в зоні чистого згину, при шпонковому та безшпонковому виконанні торців елементів, що стикуються. В результаті встановлено характер утворення і розвитку тріщин, область поширення яких зосереджена в середині прольоту в місці петльового стику балок. В основному спостерігалися нормальні тріщини, але при цьому мало місце й утворення горизонтальних тріщин. Утворення тріщин в зразках з петльовими стиками починалося з появи волосяних тріщин в розтягнутій зоні в середній частині прольоту і на межі бетону балок і бетону стику.

Ключові слова: петльовий стик, стик передерія, тріщиноутворення, чистий згин.

Introduction. In connection with a wide distribution of prefabricated-monolithic reinforced concrete in Ukraine, there was a need to increase areas of using various joints. In particular, the use of joints without welding of reinforcement, which ensure the coupling of the adjacent assembly blocks of precast and cast-in-situ reinforced concrete walls, is one of the main constructive solutions that determines the industrialization of construction, first of all hydro constructions. At the same time, the level of industrialization of construction is largely determined by process ability of the joints. When using a loop joint, there is no need in using welding.

The loop joint (Perederiya joint) represents the releases of the armature from the ends of the elements in the form of concentric loops forming rings. The concrete in the space between the rings works on a comprehensive compression.

Analysis of recent research. The loop joint was proposed by academic G.P. Perederiy and was intended for the perception of forces in bent and centrally stretched elements [1]. The first pilot studies of loop joints and structures with loop joints were led by O.N. Alperina O.Y. Berg, A.P. Vasilyev, M.V. Gnedovsky, V.K. Kachurin, A.P. Kirilov, M.G. Knyazhevich, A.M. Kushnarev, L.M. Lebel, G.P. Perederiya, R.N. Petrashen, M.M. Streletskiy, O.L. Khlebnikov, more recent studies – I.F. Blinov, I.D. Biets, B.I. Kogan, V.B. Nikolaev, O.M. Pavlikov, O.D. Rubin, S.V. Seleznev, F. Ende, P. Fonseca, J. Peschel, E. Severino, El Tawil, E. Uhle-mann, J. Wartenberg, D. Wasner [2-5]. A clear understanding of the loop joint work with loops located along the entire height of the section without overlapping in bent elements is *not* possible on the basis of the present information. However, labs in this direction made it possible to add a certain picture of the cracking of test specimens with loop joints.

Objectives of the study. The majority of researchers noted the intensive formation and development of cracks along the contour of contact between old and new concretes in the zone of the loop joint under various loads. And most of the existing recommendations are aimed at reducing cracking in such zones. In view of poor knowledge of the issue, it was decided to test the crack resistance of the splined loop joint in comparison with the keyless.

Objects and methods of research. Reinforced-concrete experimental beams measuring $10 \times 15 \times 120$ cm with loop joints in the middle of the span were made in the laboratory of Odessa State Academy of Civil Engineering and Architecture. The zone of the loop joint was concreted at a later stage. Facets of joined elements are formed with keys and without keys (Fig. 1).

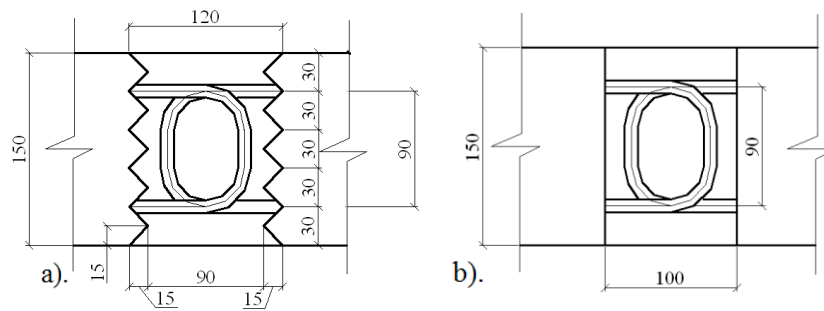


Fig. 1. Scheme of the loop joints of experimental samples:
a – splined loop joint; b – keyless loop joint

The experimental concrete beams were reinforced with two welded spatial frameworks with curved integral rods $\text{Ø}10\text{A}400\text{C}$ and two anchor rods $\text{Ø}10\text{A}400\text{C}$ in the joint area (Fig. 2).

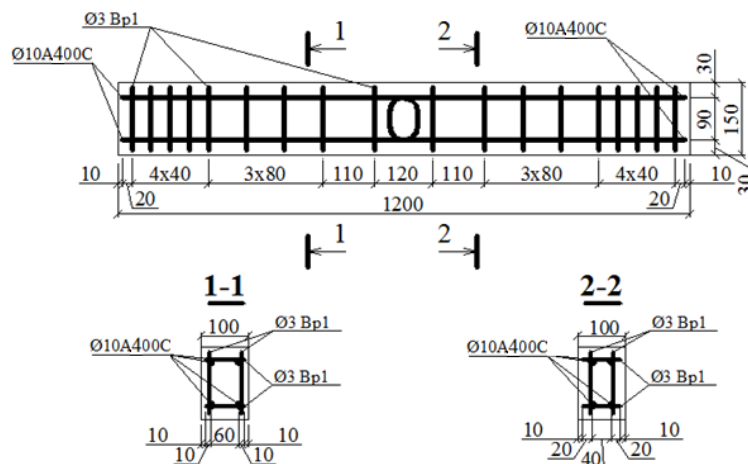


Fig. 2. Reinforcement design of the reinforced-concrete experimental beams

The scheme of loading the reinforced-concrete experimental beams is given in Fig. 3.

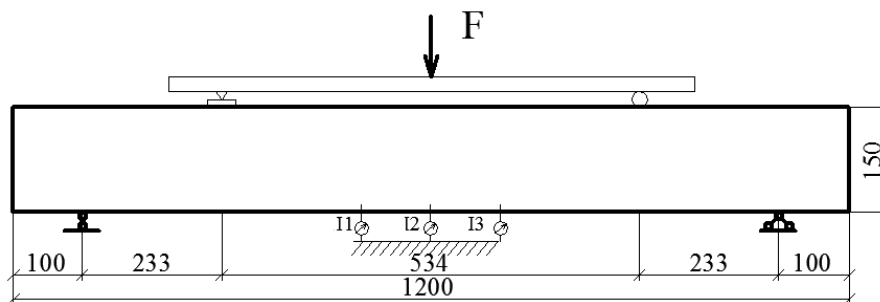


Fig. 3. Scheme of the testing of samples beams

Results of the research. The cracking and the nature of their development in the beam with splined loop joint occurred in the following order (Fig. 4). Hair-line crack appeared in the lower tension zone of the middle part of the span in the joint area at the load rate of 0.1 from breaking load. When the load increased to 0.19-0.25 from breaking load the cracking continued in the joint area and in the lower tension zone of the beam. Also, cracks appeared along the contact borderline between the old and the new concrete. At increasing the load to 0.60 from the breaking load cracks appeared in the side surface in the zone of the loop joint. At the same time, the visible to the eye crack along the contact borderline between the old and the new concrete passed to the side surfaces of the experimental sample with a splined loop joint. A crack in the beam side surface in the contact

borderline between the old and the new concrete stopped its development on the top of the first dowel key. This crack gradually developed to a size of 1/3 of the height of the section and passed two cogs only immediately before the destruction. A crack appeared in the upper compression joint

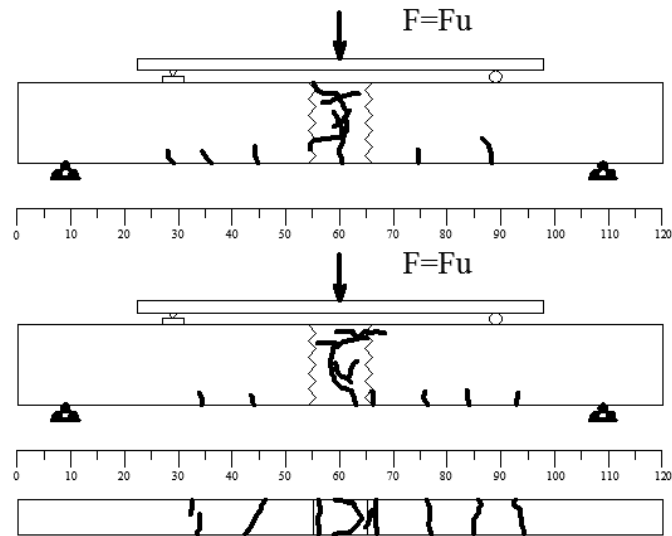


Fig. 4. Scheme of crack propagation along the side surfaces of the beams with a splined loop joint

area at the load rate of 0.9 from breaking load. The beam compression zone failure and plastic breakdown of the joint were observed due to the «scrolling» of the beam. The width of the normal crack growth before failure was 0.5-1 mm. The maximum deflection f , fixed before the failure of the beam with the splined loop joint 7.55 mm in the center of the span (indicator i_2) and 6.45 mm and 5.75 mm at a distance of 10 cm from the center of the beam (indicators i_1 and i_3).

The cracking and the nature of their development in the beam with keyless loop joint occurred in the following order (Fig. 5). Even at the very first stage hair-line crack appeared in the lower tension zone of the middle part of the span on the contact borderline between the old and the new concrete.

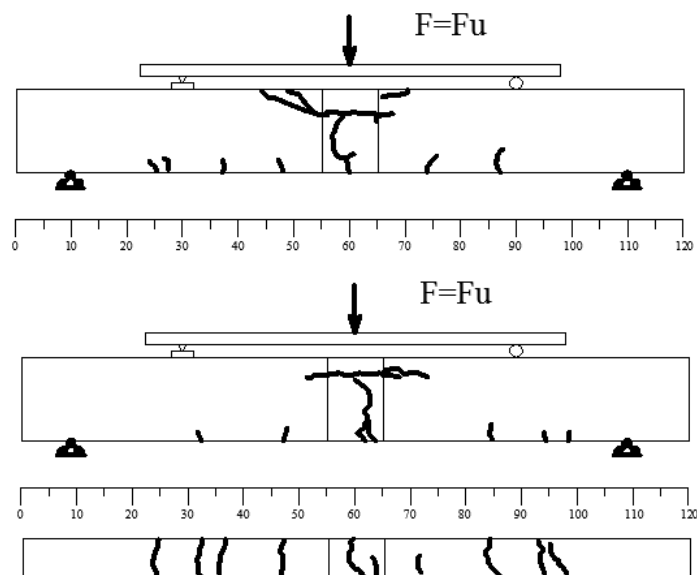


Fig. 5. Scheme of crack propagation along the side surfaces of the beams with a keyless loop joint

This crack passed to the side surfaces of the experimental sample at a load rate of 0.18 from breaking load. With the load increased first to 0.18 and then to 0.36 from breaking load, formation and development of a horizontal crack along the reinforcement in the compressed joint zone was noted. The horizontal crack opening continued with a further increment of load. A crack in the beam side surface in the contact borderline between the old and the new concrete developed to a size of 1/3 of the section height. A normal crack appeared in the lower tensile side in the middle part of the span (in the zone of the loop joint) at the load rate of 0.46 from breaking load. With a further increment of load simultaneous gradual crack opening along the contact borderline between the old and the new concrete and normal crack opening in the zone of the loop joint in the middle part of the span were seen. The Horizontal crack in the compression area passed into the body of the jointed elements at the load rate of 0.58-0.64 from breaking load. The beam joint concrete failure in compression zone was observed at a load of 55 kN due to the «scrolling» of the beam. The maximum deflection f , fixed before the failure of the beam with the keyless loop joint, was 8.35 mm in the center of the span (indicator i_2) and 8.16 mm and 7.4 mm at a distance of 10 cm from the center of the beam (indicators i_1 and i_3).

Conclusions. The nature of the formation and development of cracks was established. Cracks were concentrated in the middle of the span in the place of the loop joint. In general, normal cracks were observed, but horizontal cracks also occurred.

Cracking in samples with loop joints began with the appearance of hair cracks in the tensile side in the middle part of the span and at the border of beams and joints concrete.

Due to the jagged form of the keyed joint, the development of a crack along the border of old and new concrete in such joints was delayed at the tops of the «teeth».

Experimental research in this area should be continued in the light of evolving precast and cast-in-situ reinforced concrete structural systems using loop joints without welding of reinforcement on the Ukrainian market.

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