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THE IMPACT OF THE ANCHORAGE AND ANGLE OF THE BONDED ANCHORS IN THE CONCRETE SUBSTRATE ON THE TYPE OF FAILURE

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1. Introduction

The use of new anchorages is a phenomenon often found in engineering practice [1, 2, 3]. The full range of anchors includes: simple anchor bolts, straight bending screws, bolts with a hook, bolts with anchor plate from the group of pasted anchors and screws with an expanding cone, i.e. mechanical anchors, used as bolt anchors, sleeve anchors, hammered anchors with thread internal ones that are particularly suitable for small anchoring depths.

The next group are nail anchors, which include the previously mentioned screws with a hook. The assortment of anchors available on the market depends on the material in which it will be applied. In this article, research and application description apply to simple bonded anchors in the form of threaded rods applied in concrete. The work of oblique anchors and their role in strengthening the construction of three-layer walls of large-panel buildings are also considered.

2. Research stand

The tests were carried out at the Bialystok University of Technology in Bialystok using a hydraulic load feeding system HYSDOZOK (fig. 1).

Figure 1 – View of the research stand

The system consists of a single-pump power supply unit, a wiring-joint installation, ten independent control units and a mobile operator station [4, 5]. The test stand was equipped with a hydraulic cylinder for setting the vertical (bursting) gain with a step of 0.5 kN/s [6] up to a load limit value of 80 kN. When testing the anchorages installed at an angle of 90^0 in three-layer samples, a horizontal actuator was additionally mounted on the test bench to create a shear force on the surface layer of concrete with a constant load of 1.4 kN (fig. 2).

3. The course of research results

The research is part of the main research carried out for the author's doctoral dissertation. An integral part of the research are anchors mounted at an angle as part of a set of anchors modeled on the COPY-ECO system [7]. The author prepared a research plan, which assumed the design of a retaining plate, mounted for the time of testing on the top of the sample. The thrust slab rested on the rollers, thus eliminating the effects of friction between the surface of the board and the concrete sample.

The thrust slab was attached to the beam of the test stand by means of M22 screws.

Figure 2 – The course of testing the sample anchored at an angle of 90^0

Table 1 – List of parameters of samples anchored at an angle of 90 degrees and results of their tests

Type of samples	Concrete class	Type of resin	Embedment depth [mm]	Anchorage angle [^{0}]	Destructive force [kN]	Limit force [kN]	Difference [%]
three-layer	$C^{12}/_{15}$	AnchorFix-1	20	90	6,00	13,46	55,42
		R-KER			5,70	8,43	32,38
		AnchorFix-1	40		8,50	25,52	66,69
		R-KER			5,00	15,47	67,68
		AnchorFix-1	60		7,90	37,57	78,97
		R-KER			10,50	22,50	53,33

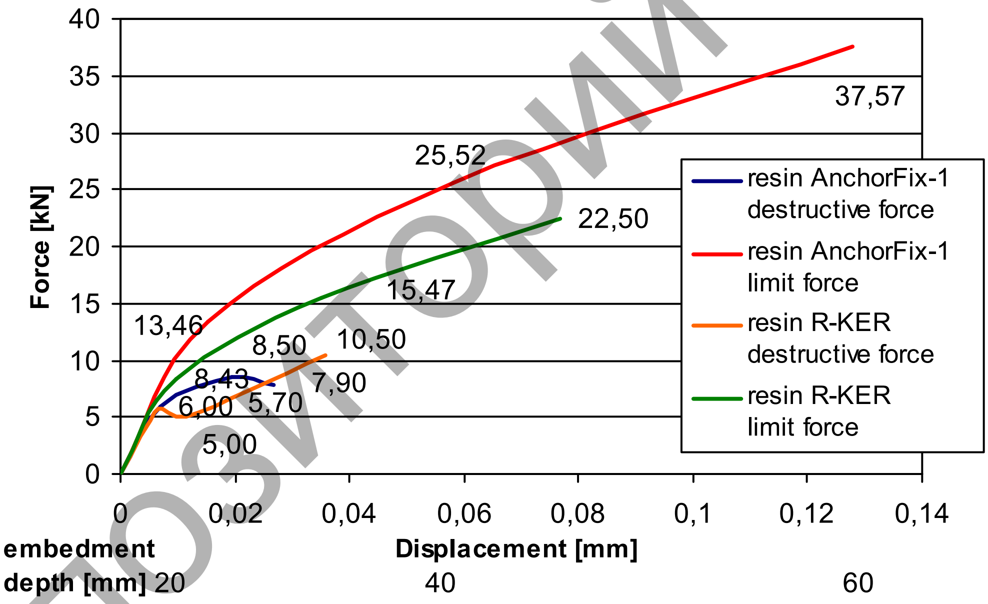

Figure 3 – Force-displacement graph depending on the type of resin and anchorage depth mounted at an angle of 90^0.

Figure 4 – The course of testing the sample anchored at an angle of 60^0

Table 2 – List of parameters of samples anchored at an angle of 60 degrees and results of their tests

Typ próbek	Klasa betonu	Rodzaj żywicy	Głębokość zakotwienia [mm]	Kąt zakotwienia [^{0}]	Siła niszcząca [kN]	Siła graniczna [kN]	Różnica [%]
three-layer	C 12/15	AnchorFix-1	40	60	11,25	12,06	6,72
		AnchorFix-1			9,10	12,06	24,54

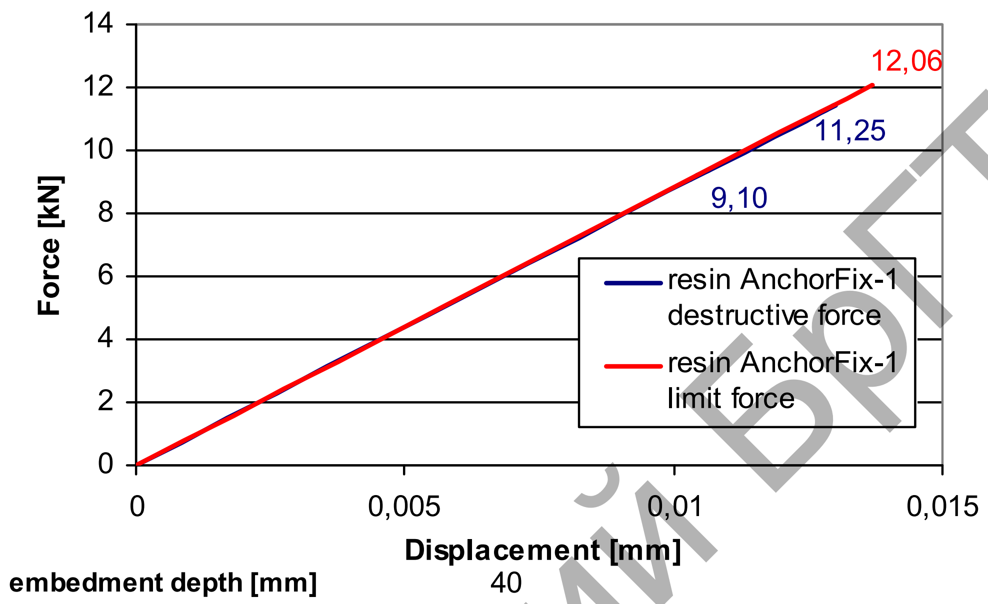

Figure 5 – Force-displacement graph depending on one type of resin and one embedment depth

Figure 6 – The course of testing the sample anchored at an angle of 45^0

Table 3 – List of parameters of samples anchored at an angle of 45 degrees and results of their tests

Typ próbek	Klasa betonu	Rodzaj żywicy	Głębokość zakotwienia [mm]	Kąt zakotwienia [^{0}]	Siła niszcząca [kN]	Siła graniczna [kN]	Różnica [%]
three-layer	C 12/15	AnchorFix-1	40	45	3,50	17,05	79,47
		AnchorFix-1			4,20	17,05	75,37

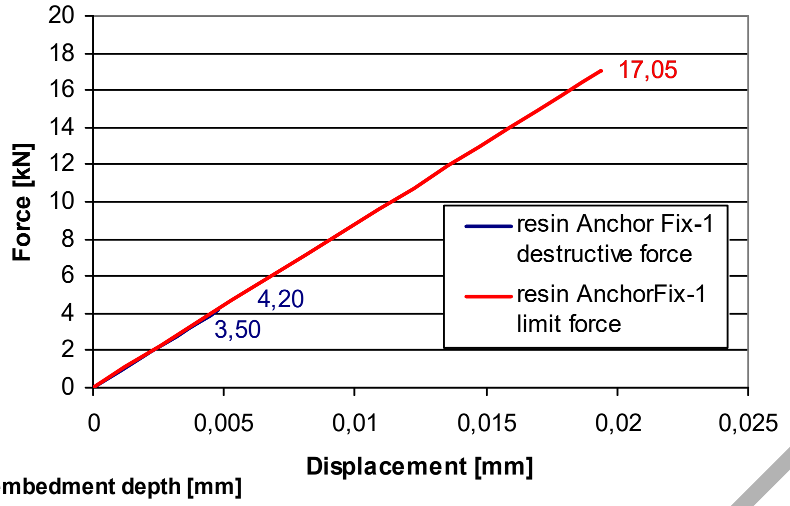

Figure 7 – Force-displacement graph depending on one type of resin and one embedment depth

Figure 8 – Przebieg badania próbki zakotwionej pod kątem 30^0

Table 4 – List of parameters of samples anchored at an angle of 30 degrees and results of their tests

Typ próbek	Klasa betonu	Rodzaj żywicy	Głębokość zakotwienia [mm]	Kąt zakotwienia [^{0}]	Siła niszcząca [kN]	Siła graniczna [kN]	Różnica [%]
single-layer	C 12/15	AnchorFix-1	95	30	10,60	49,62	78,64
		R-KER			11,90	28,94	58,88

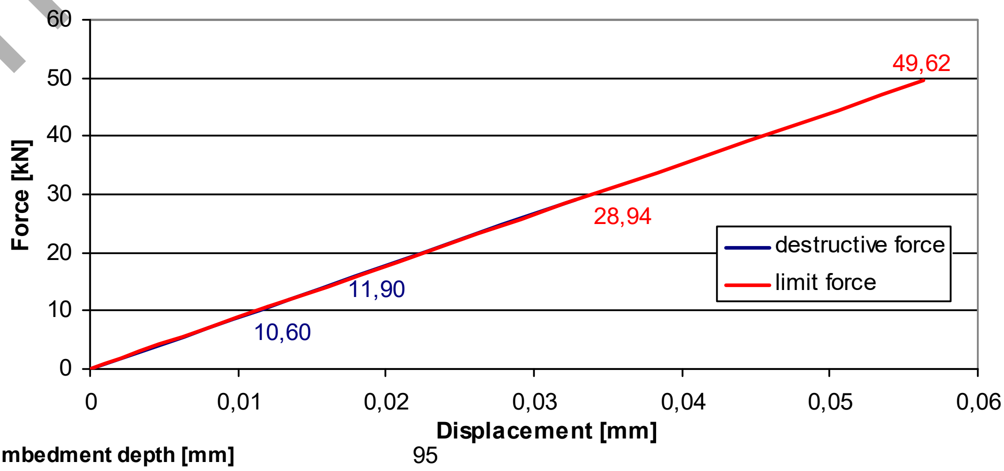

Figure 9 – Force-displacement graph depending on one type of resin and one embedment depth.

4. Conclusions

There is no doubt that the use of diagonal anchorages significantly reduces the load on perpendicular anchors. In addition, these anchorages take over the tensile stresses. It can therefore be concluded that the use of two oblique anchorages as a single connector system will fulfill its role in extending the durability of the connections of the three-layer walls of large-panel slab buildings. Oblique anchors transfer tensile stresses and their relationship in the force-displacement relationship is linear for both the breaking force and the boundary force, regardless of the resin used, the angle of inclination and the depth of anchoring. In the case of testing the load capacity of diagonal anchors, the force-displacement dependencies both in the case of breaking force and boundary force are of linear nature regardless of the angle of the anchor, type of resin or embedment depth. Differences in the values of forces reaching almost 80% of the difference resulted from the fact of anchoring design in difficult weather conditions (low temperature, rainfall).

The most important fact, which is the whole interpretation in this type of connections, is the thorough cleaning and thorough distribution of the resin at the anchorage site.

References

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