DETECTION OF DAMAGED PROPS AND THEIR POTENTIAL IMPACT ON STRUCTURAL STABILITY DURING CONSTRUCTION

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Abstract

Steel props play a key role in providing stability to floor slabs during construction. Their technical condition significantly affects expansion capability and safety. Props in inadequate technical conditions may lead to uneven load transfer and stability risks. This article analyses the impact of support conditions on functionality and the risks associated with using damaged elements in construction practice.

Keywords

Props, slabs, construction, technical condition

1 INTRODUCTION

Almost every new structure is designed for a live load that represents only a small fraction of the total design load. In many structures, the sum of the designed live load and dead load accounts for only 40% of the self-weight of the concrete floor, and in residential buildings, it is often less than 25%. As a result, the recently completed slab beneath it cannot support the newly cast slab, and the structural load must be transferred to the lower floor slabs. This load redistribution is achieved using props, which must be securely fixed between floors [1]. Props are equipped with a threaded mechanism that allows for height adjustment and secure positioning between floors [2]. The fixation process induces an additional load on the structure, ranging from 1 kN to 14 kN [3], [4]. However, the exact magnitude of the additional load introduced by props in poor technical condition, as well as their ratio to undamaged props, remains unclear.

The fixation of props is typically carried out by hammering their threaded sections. In construction practice, workers rarely, if ever, fully tighten a prop to achieve zero clearance. Instead, they commonly apply a few hammer blows to secure the prop between the slabs [5]. Due to the flexibility of floor slabs, the preloading of one prop may cause adjacent props to loosen, leading to uneven preloading across all props [6]. The force exerted by workers during prop fixation is also influenced by the technical condition of the props. Worn-out props or those with clogged threads require greater force for fixation compared to props in good physical condition. In such cases, workers may continue applying the same force even when the threaded connection develops clearance, potentially leading to excessive stress in the prop and, consequently, additional loads on the floor slabs.

Supports according to EN 1065

The European standard EN-1065 specifies the materials, structural requirements, and corrosion protection options for adjustable telescopic steel props (hereafter referred to simply as "props") with both covered and uncovered threads [7]. EN-1065 applies to telescopic steel props and defines the requirements for their design, manufacturing, inspection, testing, and marking. It is a European standard used in construction to provide safety and quality of steel props. The quality of props used on construction sites is verified by a certificate confirming that the properties of the props meet this standard. EN-1065 establishes the strictest global requirements for materials, structural specifications, and protective measures against corrosion [8]. All materials must comply with existing European standards, and all components must be protected against corrosion. The standard defines five corrosion protection

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methods, classified according to the manufacturing process with the applied method indicated on the prop's marking.

The primary specification of props is their load-bearing capacity. According to the standard, the load-bearing capacity is defined as the minimum external load that can activate collapse mechanisms due to tube bending failure [9]. The cross-sections of the tubes must comply with international reference standards. The nominal thickness of any tube (including tolerances) must not be less than 2.6 mm for props in classes B, C, D, and E, and at least 2.3 mm for props in class A. The inner and outer tubes must overlap by at least l_o≥300 mm when the prop is fully extended [7], [10].

Technical condition of the props

Due to their significant working heights and high load-bearing capacity, these components are subjected to substantial compressive and tensile forces. This would not play a role in single-use applications, props are used repeatedly, and such repeated usage can significantly contribute to material fatigue [11].

Routine inspection of props is the first step in their maintenance. Regular inspections help prevent accidents, costly damages, and repairs. In general, before using props, a visual and mechanical assessment must be carried out to determine their suitability [12]. The key inspections include:

- **Surface inspection:** a visual check of the outer surface for rust, dents, or other physical damage.
- **Thread inspection:** an examination of the prop's threads for dirt and damage. Proper functioning requires smooth and unobstructed rotation of the threaded mechanism.
- **Locking mechanism inspection:** checking the pins that secure the props at the required height to ensure they are undamaged and free from debris that could prevent proper locking. The holes for the locking pins should also be examined for potential damage, especially signs of tube cutting.
- **Load capacity verification:** ensuring that the props are not overloaded, as excessive loads can lead to damage and safety hazards.
- **Adjustment mechanism:** testing whether the props can be smoothly and securely adjusted. Any resistance or difficulty in adjustment could indicate damage or mechanical contamination.

If any damage or deformation is detected, the affected props must be replaced. A steel prop consists of multiple components with varying strengths: an inner tube with a top plate, an outer tube with a bottom plate and external threading, an adjustment handle, and a locking pin. Any of these components may be in a technically unsatisfactory condition or exhibit some form of damage [13]. However, given the high number of props used on construction sites, it is impractical for workers to inspect each one individually. As a result, props are often used even when their technical condition is not checked.

2 METHODOLOGY

The technical condition of the borrowed steel props was first analysed as a part of the research methodology. The assessment included a visual inspection of surface damage, corrosion, wear of the threaded mechanism, and the functionality of the fixing elements. The objective was to identify potential deficiencies that could affect the mechanical properties of the props and their ability to evenly transfer loads. Following the initial analysis, experimental measurements of the fixation level of the props between individual floors were conducted. The testing was carried out under controlled conditions simulating real construction loads. The measurements included various fixation methods, monitoring the preloading force generated by manual tightening and hammer blows to the thread. The collected data allows for a comparison of fixation differences in props with varying technical conditions and evaluation of their impact on structural loading.

The measurements were conducted on a custom-built steel structure with dimensions of 500 × 500 mm, equipped with four calibrated strain gauge sensors (see Fig. 1). Three fixation levels were assessed on this setup: maximum manual fixation, fixation after three hammer blows, and fixation after five hammer blows. A total of seven construction workers from various sites across Slovakia and abroad participated in the testing. The weight of the workers was recorded; however, it was found to have no significant impact on the final fixation results. The obtained data were compared with a new prop, the Doka Eurex 20 Top 300, which is one of the most commonly used props in Slovakia.

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Analysis of tested samples

Props were borrowed from the largest formwork and prop suppliers in Slovakia as part of the technical condition analysis of randomly selected props. The study focused on evaluating the visual technical condition of the props, as well as the method and difficulty of their fixation. A total of 11 props from various manufacturers were tested in the experiment. For the largest manufacturers, two versions were examined: an unused prop and a used prop. Tthree props from the tested samples were identified as having the worst visual technical condition. These included the Alpiprop ST B30-175/300; MUBA Euro Baustutzen der klas B/D35-196/350 and ULMA EP C+D30, 20-35/180-300. The remaining props appeared to be in good condition and suitable based on visual inspection.

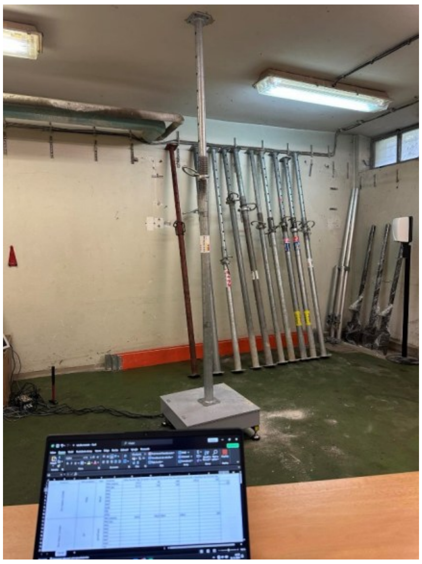

Fig. 1 Measurement using strain gauges.

Alpiprop ST B30-175/300

The prop exhibited significant physical wear and tear on its contact surfaces, along with noticeable deformations, which prevented it from standing independently and caused it to rotate during fixation (see Fig. 2). The threaded rod was heavily contaminated with concrete or cement residue, obstructing the smooth rotation of the thread around its axis. When tightened manually, the prop could not be fixed between floor slabs, as human force alone was insufficient to overcome the contamination in the thread. The thread was not lubricated, making its movement difficult and prone to jamming. Additionally, the thread had defects, such as a bent thread rail, which prevented the crank handle from passing through. The technical condition of the prop was classified as unsatisfactory, making it unsuitable for use on the construction sites. It was recommended to decommission this prop.

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Fig. 2 Broken thread on the support.

MUBA Euro Baustutzen der klas B/D35-196/350

The MUBA props exhibited deformations on the contact surface edges at both the top and bottom steel plates (see Fig. 3). Similar to the previous prop, this deformation caused the prop to rotate during fixation and resulted in an uneven distribution of pressure on the floor slab. At the top section, near the joint between the tube and the top plate, minor defects were present, including cracks near the welds. The thread was cleaned; however, the upper section had deformed thread rails. The technical condition can be classified as moderately severe, and it was recommended the prop to undergo technical adjustments or be decommissioned.

Fig. 3 Bent steel plate.

ULMA EP C+D30, 20-35/180-300

Only one defect was identified for the ULMA prop a dent on the prop’s thread. In this case, the dent did not hinder the functionality of the prop; however, additional force was required during fixation to allow the nut to overcome this defect. The technical condition can be classified as satisfactory, requiring only minor technical adjustments.

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3 RESULTS

The difference in the resulting stress generated during the fixation of props between ceiling slabs is significant. The most damaged prop, on average, induces an additional stress of 1.99 kN on the structure, while the prop with the least damage prop generated an additional stress of up to 7.65 kN across seven different measurements. The difference between the induced loads was 5.66 kN. Tab. 2 shows measurements for a new prop from Doka. The average induced stress was 7.65 kN, with a maximum stress recorded at 11.22 kN for a single prop. The tables demonstrate that props with specific damages reach lower stress values compared to the new prop in perfect condition. Specifically, for the Alpiprop, the difference was 5.66 kN, for the Muba prop, it wass 4.19 kN, and for the least damaged Scaform prop, the difference was 2.64 kN. Much larger differences could be observed when fixation was done with three hammer strikes. The average induced stress for the Alpiprop was 0.70 kN, for the Muba prop 1.90 kN, and for the Scaform prop 2.25 kN (see Tab. 1), whereas for the new prop, the average was 5.18 kN (see Tab. 2)

Tab. 1 Measured values during the fixation of props.

	Props weight (kg)	**Subjects**	**Worker's weight (kg)**	**Manual tightening (kN)**	**Average-Manual tightening (kN)**	**Fix- 3x hammer strike (kN)**	**Average-Fix- 3x hammer strike (kN)**	**Fix- 5x hammer strike (kN)**	**Average-Fix- 5x hammer strike (kN)**
ALPIPROP ST B30-175/300	14.5	1	112.5	N		0.95		1.29	
		2	117.5	N		0.54		0.97	
		3	102	N		0.53		1.23	
		4	120	N		0.59		1.09	
		5	108	N		0.71		1.41	
		6	79	N		0.74		2.76	
		7	83	N	**N**	0.87	**0.70**	5.17	**1.99**
MUBA Euro Baustutzen der klas B/D35-196/350	19	1	112.5	1.50		2.71		3.91	
		2	117.5	0.27		1.58		2.60	
		3	102	0.72		0.93		2.03	
		4	120	0.78		1.33		2.63	
		5	108	0.94		1.66		2.31	
		6	79	1.06		2.79		5.28	
		7	83	1.07	**0.91**	2.29	**1.90**	5.45	**3.46**
Scafom-rux EP20-300, D30	15	1	112.5	1.66		2.41		3.78	
		2	117.5	0.91		1.65		4.31	
		3	102	1.01		1.59		5.38	
		4	120	0.57		1.37		3.59	
		5	108	1.04		1.97		3.90	
		6	79	0.27		3.22		6.44	
		7	83	0.64	**0.87**	3.49	**2.24**	7.70	**5.01**

*Note: N - Manual tightening could not be measured due to the thread obstruction of the prop

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Tab. 2 Measurements of the new Doka prop.

	Props weight (kg)	Subjects	Worker's weight (kg)	Manual tightening (kN)	Average-Manual tightening (kN)	Fix- 3x hammer strike (kN)	Average-Fix- 3x hammer strike (kN)	Fix- 5x hammer strike (kN)	Average-Fix- 5x hammer strike (kN)
Doka Eurex 20 top- 300	14	1	112.5	1.29		4.82		8.48	
		2	117.5	1.22		4.60		5.88	
		3	102	3.75		3.87		4.53	
		4	120	2.21		4.40		6.41	
		5	108	2.37		4.91		6.39	
		6	79	1.18		6.81		11.22	
		7	83	1.32	**1.91**	6.87	**5.18**	10.63	**7.65**

4 DISCUSSION

The measurements and analysis of the stresses in the propt structures reveal significant differences between damaged and undamaged props, which have a substantial impact on the structure stability. The most damaged props generated, on average, only 1.99 kN of stress, while undamaged props reached an average of 7.65 kN, creating a difference of 5.66 kN. This difference indicates that the extent of damage significantly affects the ability of the prop to be effectively fixed between the ceiling panels. The inclusion of props with reduced technical capability into the load distribution system can lead to structural problems. Misalignment in prop fixation causes slight deviations between ceiling panels due to higher stresses generated by props in good condition. Such imbalance may lead either to the collapse of damaged props, posing a risk to workers, or their failure to transfer loads properly. As a result, the load from the ceiling panel is transferred to props with stronger fixation, which may lead to their overloading or deformation, as the design load assumes equal bearing capacity across all props. Improper prop distribution may cause uneven force distribution, leading to excessive loading of certain areas and creating additional bending or shear moments at the joints between the props and ceiling panels. This can result in cracks or other damage to the ceiling panels. Insufficiently fixed or damaged props may, therefore, cause gradual structural collapse, presenting a risk to people and the surrounding area of the construction site.

5 CONCLUSION

Based on these findings, it can be confirmed that the technical condition of the props directly affects their ability to be fixed and the stress applied to the structure, which can compromise the structure stability and the safety of workers. It was shown that even with a random selection of props from suppliers, there is a risk of receiving props in an unsuitable condition – in our case, three out of eleven props did not meet the required standards. Although this finding is not statistically representative of the overall use of props on construction sites, it highlights the fact that damaged props are not being discarded by suppliers but are repeatedly used on construction sites.

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