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On-site Safety Considerations for Scaffoldings: A Case Study

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Abstract

As widely accepted, scaffolding works are one of the temporary facility in a construction project. However, its impact on a project is very significant, so they must be comprehensively planned, designed and erected. The current practices on these are often manual and reactive, and abnormally performed while the project is on-going. In Turkey, there are no legal regulations for the manufacturers of scaffoldings. Only some legal requirements are used for scaffolding works, especially on the construction sites. For these reasons, a simple and confidential design analysis method can be efficiently and effectively searched by the practitioners. In order to make a contribution to the relevant studies, this research has been conducted. This paper presents the results of a research whose aim was to introduce a new perspective view on the safety regulations of scaffolding production and erection works on a construction site for examining a case study.

Keywords: Scaffolding, scaffolding safety, scaffolding safety analysis, preventing scaffolding accidents

1. Introduction

The construction sector is one of the riskiest line of business due to the occupational accidents, their frequencies and related serious consequences. It is a vital necessity and priority for the employers and employees in all parts of the implementation to comply with occupational safety rules under any circumstances. In addition to that, that the examination of the accidents that have occurred and the reports related to them, should be considered as the most accurate source for the development and updating of the relevant rules.

Too many employees face the risk of either losing their lives or becoming disabled every year as a result of occupational accidents that have occurred in the construction sector in Turkey. Also, huge social and economic losses are experienced due to these accidents. According to the data provided by Turkish social security institution, about 22 occupational accident occur per each work day, 2.68 per each work hour and 1 per each work hour. Also about 1.2 people becomes injured and 1 person losses his life in each work day. When we make an evaluation in a manner encompassing all sectors, 1.6% of the work accidents resulted in death and this value rises to 4.7% in the construction sector [1].

One of the most prominent and important causes of the occupational accidents in the construction sector are due to fall from height. This situation is not only a fact in Turkey but also applies to many European countries [2]. Despite these high rates in Turkey as well as in Europe, the regulations to prevent this type of accidents remain incapable in Europe [3]. EN 12810, EN 12811 and similar Turkish standards serves only to inform about its manufacturing and erection [4].

Many analyses have been carried out about the falling from the scaffolding. They can be classified

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as accidental falls [5], fatal event analysis [6] and scaffolding materials-related [7]. Some researchers have studied upon the relationship between falling from height and work equipment with the survey-based studies [8, 9]. In view of some researchers, changing the habits of employees on work safety will play a role as the biggest factor in the decline of these accidents [10].

With the research in this study, it has been thought to contribute to the relevant standards and regulations by focusing on the hinge formation in scaffolding load-bearing system and examining an accident occurred due to transfer of moment to the dowels that cannot be borne.

2. Suspended scaffoldings operated with electric motor

The scaffolding where it was used for the renovation works in the building and the accident occurred, is a temporary construction maintenance unit which is known as "suspended scaffolding operated with electric motor" in practice and frequently used especially for exterior siding and maintenance operations of high-rise buildings. These units simply consist of a platform, lifting mechanisms and the suspension legs where the ropes are tied on the terrace. It climbs vertically along the facade on the ropes with climbing mechanisms facilitated its movement by the electric motors mounted on the platform. The wheels connected to the platform allow the platform moves in equilibrium along the facade.

That the platform on which the work is done, moves safely along the facade and ensuring the state of equilibrium are achieved by anchoring the suspensions legs on terrace to the bridge floor concrete (Fig. 1) The life ropes tied to a constant point on terrace are suspended along with the platform movement direction at the facade in order to ensure the safety in the event of any negative situation for the workers who work on the platform.

Figure 1 Suspended scaffolding suspension leg

3. Determination of used electric motor operated scaffolding on a construction site

Two scaffoldings with the same dimensions and properties were used in the building for the maintenance and repair (exterior insulation) works. The scaffolding available to operate during the exploration and the scaffolding where the accident occurred are located at the different fronts. (Fig. 2).

Figure 2. Side facade of building, Rear facade of building

The scaffolding in investigation was fixed to the building by means of two suspension legs on the terrace. (Fig. 3).

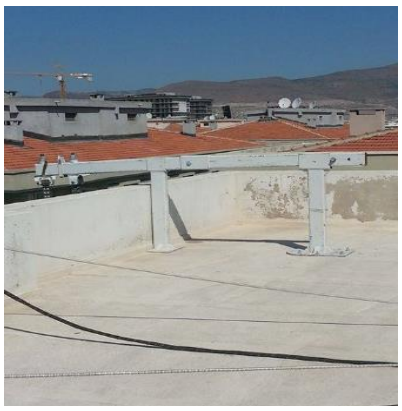

Figure 3. Suspension leg connection

Figure 4. Bridge floor concrete and base plate

As shown in Figure 4, the connection of suspension legs to the building is provided by 6 chemical dowels/anchors used between base plate and the bridge floor.

The platform fixed to building with suspensions legs can go along the facade via two electric motors enabling movement on the chains attached to the legs. The upward and downward movement, upward run and downward run of electric motor are performed by a cableway control system with one key related Fig. 5).

Figure 5. The chain attaching the platform to suspension leg

4. Accident happening and engineering calculations

It was stated that the scaffolding was first at the suspension state then collapsed following its separation from its left connection point. It was observed that the technically appropriate and necessary calculations of scaffolding system consisting work platform, motor, chain structure, suspension legs and fixing plate were performed and it is a safe practice work safety measures were taken with the railings and 3 lifelines. Hence, no deformation and damage at the chains and gears carrying the scaffolding were happened due to the accident. When the structure of concrete located on the terrace and where the chemical dowels were mounted in a detailed manner, it was observed that there were two different layers on this part of bridge floor as one was levelling concrete and the other was mosaic coating.

Since the system had worked for a month before the accident happening without accident, the hinge formation applied to the existing layered surface was observed to have the capacity to bear the load portion of transmitted to mounting dowels from nominal 3100 kg load of scaffolding under normal operating conditions in a safe manner.

The carrying capacity of a dowel with a pressure gauge used during the test was found to be very much more than 1400 kg. The tensile strength of 209 kg coming to dowel at the most negative situation under normal operating conditions can be carried safely with minimum 7-fold when the capacity of a dowel is considered to be 1400.

As stated above, excessive forcing due to stopping the left end of scaffolding by obstruction of air conditioning installation leg and its blocked movement caused to hinge formation at the connection point and as a result of this, caused a moment transferred to the dowels which they cannot bear and for that reason the accident in question happened. Engineering safety calculations were performed as follows:

The force required to reach a rupture in carrying chain can be obtained from the engineering calculations as expressed below. Dimensions of the support foot were recorded and the standard calculation methodologies (TS EN 648) were applied for welded parts at the corners.

The maximum weld towing capacity for Steel 52 as per the standard TS EN 648 is $\sigma max=52kgf/mm2$. F value is the resultant tensile force of the accident. Then F is calculated as; $F= \sigma max*\sum Ak= 52*2*45*8 = 37440$ kg. In order to calculate the force at the ending zone of the supported leg, the static behavior of the system should be taken into account (Fig 6).

The “P” (Fig. 7) value which gives to the load transferred by the scaffolding platform at the time of accident and calculated as follows: $F*10=P*88$ (For F=37.440 kg) and it was obtained as P=4.254 kg.

The rupture is located in the articulation zone of the system and equilibrium equations must be provided for the balance of the whole system.

As the result of the above performed calculations done regarding this situation 39.6 tons of force fell on the dowel at the most negative point. This force cannot be carried regardless of kind of

anchoring done

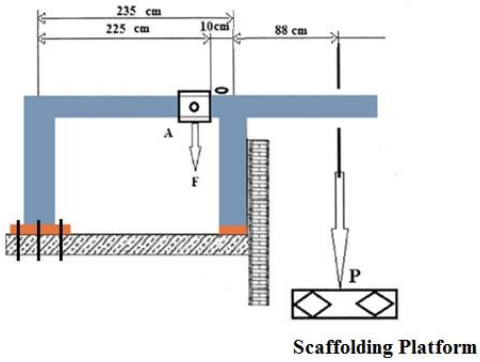

Figure 7. Scaffolding Platform and Supporting Leg

Figure 6. Corner Weld Application

5. Evaluations

The following determinations and evaluations have been done regarding the accident as a result of both technical calculations and investigations performed in the accident site.

1. In terms of job security in the scaffolding system, there are 3 lifelines and 100 cm guards at the platform edges.
2. In case of present assembly state, the scaffolding has the capacity of carrying the normal work load. In fact, the system served approximately 1 month before the accident. It was observed that the dowels have the capacity of carrying the force minimum 7 fold safety under normal conditions for the dowel at the most negative point.
3. The accident happened due to obstruction of left end by the air conditioning leg during the movement between the floors and excessive forcing to that side causing to hinge formation and as a result of this, falling a 39,6 ton force to the dowel at the most negative point. It is not possible to carry such a high force with any kind of anchoring.
4. It is understood that three lifelines available on the scaffolding were not used during the accident. If these lifelines had been used, then the casualties could have been prevented from occurring

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