Scaffolding and falsework

STEP lecture E8
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Objectives

To describe scaffolding systems and their load bearing elements, and to explain the main factors which have an influence on the safety and stability of the construction.

Summary

The lecture gives a short introduction to the subject by mentioning the purpose, history and development of such temporary structures. Requirements, structure systems, loads and particular details in scaffolding are briefly covered. A recently developed nailplate based falsework is described. The combined use of steel and timber in a heavy structure by a bridge construction completes the lecture.

Introduction

In many cases a supporting framework of scaffolding is needed during the construction (or dismantling) of a structure. For workers, platforms may be used during the construction, repair, painting or cleaning of buildings. Even though scaffolding and falsework are temporary structures they have to be designed and treated seriously and according to the same principles as if they were permanent structures. Collapse involves risks for human life or serious injuries and also has economic consequences. Many countries have regulations or codes, in particular, to ensure the safety of human life.

In Asia bamboo is widely used for scaffolding. In Europe scaffolding and falsework in former days with few exceptions were made of timber and constructed on the site. Some of the old structures were huge and impressive and often based on complex structural systems. It required certainly good design, material knowledge and workmanship of high quality. Figure 1 shows the falsework system by the Svinesund road bridge, an arch bridge at the border between Sweden and the south-eastern part of Norway (built 1938-42).

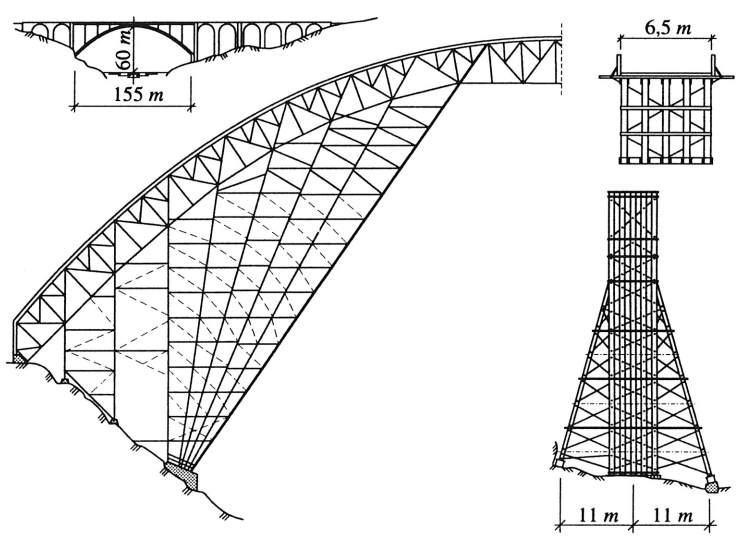

Figure 1 Falsework at Svinesund bridge (Aune, 1994).

In recent years, however, a great number of flexible elements and systems have been marketed. The elements may be made of steel (often steel tubes) and aluminium profiles, light weight, easy adjustments, and simple connections. The fact that such systems may be used over and over again represents of course great advantages. Even so a lot of scaffolding and falsework is still made of timber.

EC5 has no specific rules covering such constructions, and this lecture deals with general principles in design and refers to the national specifications and practice in some European countries.

Scaffolding

Norway is one of the countries where there are regulations concerning scaffolding. The regulations are worked out by the National Labour Commission and are quite detailed. They have to be regarded as any specification. The main purpose which is strongly emphasised, is consideration of the safety of workers and people in general. This implies requirements for particular details, as well as for a sufficient load bearing capacity of the structure as a whole.

The timber used should be of a structural grade and unpainted. If second hand the material must be undamaged. Similar to the assumptions in EC5 regarding the qualifications of the designer and other persons involved, scaffolding work should be carried out by skilled people. It is the employer's responsibility to provide a final control/inspection before the scaffolding is used. It is important to provide signs giving details of the owner, the designer and the design loads.

Loads

Experience over recent decades has provided the background for the present classification of scaffolding according to load values in six classes. The given uniformly distributed loads over the whole platform area vary between 0,75 and 6,00 kN/m^2 (CEN, 1988). In addition there should be two concentrated loads, one distributed over a certain area and the other the weight of one person. The position of these loads shall be chosen to represent the most unfavourable conditions. Also load actions due to wind forces according to the National load specifications, have to be included.

Load bearing system and bracings

In Figure 2 a typical scaffolding system is shown (CEN, 1988). Main components are identified by numbers in the caption of Figure 2. The loads carried by the platform may be transferred to the ledger and further to the transom and finally to the standard, see Figure 3a. By the system shown in Figure 3b the loads are transferred directly to the transom and then to the standard. The joints must be designed accordingly. The purpose of the plane brace is to keep the system in a rectangular shape in the horizontal plane. The longitudinal and the lateral braces provide stability in the respective vertical planes and directions. The tie members fix the scaffolding to the wall.

Detailing

The guard rails shall be designed to resist a required concentrated load (vertical or horizontal) at the ultimate limit state situation. There is a similar requirement (smaller load) to meet the serviceability situation.

For some scaffolding a toeboard might be required at the platform. The standards should preferably be in one length, but if necessary they might be jointed by butt joints and long gusset plates along two or four sides. Access to the platforms should be safe, comfortable and suitable preferably a stairway (with a guardrail). For long stairways a landing is required.

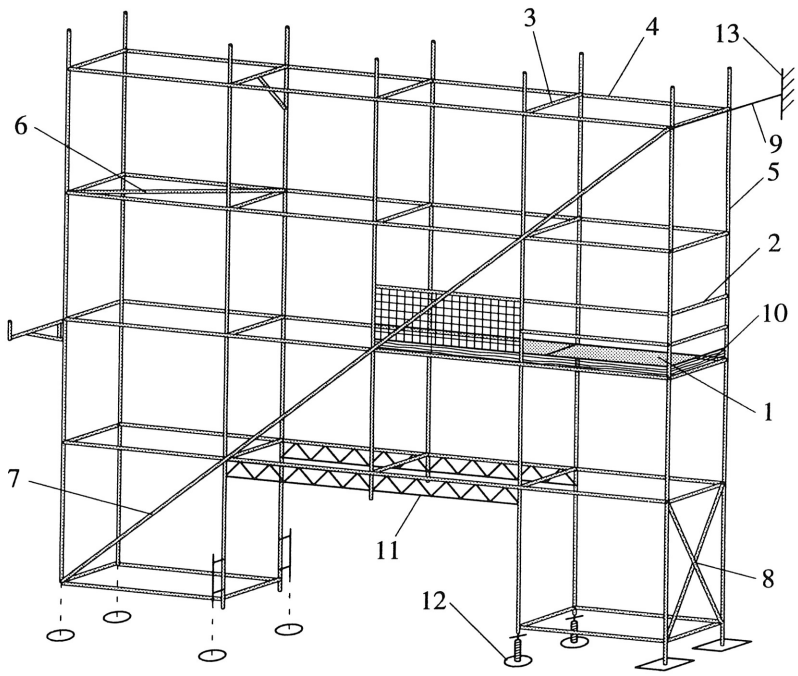

Figure 2 *Scaffolding structure (Identification according to CEN, 1988). (1) Platform, (2) guardrail, (3) transom, (4) ledger, (5) standard, (6) plane brace, (7) longitudinal brace, (8) lateral brace, (9) tie member, (10) toe boards, (11) bridging ledger, (12) base plate, (13) wall support.*

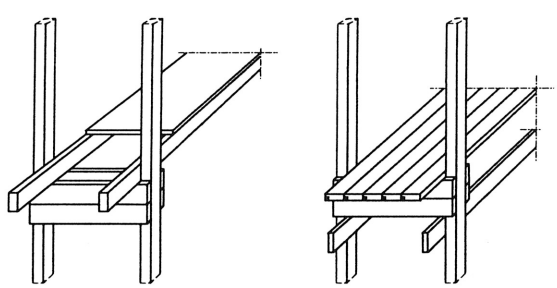

Figure 3 *Different load-bearing systems (Arbeidstilsynet, 1989).*

Falsework

Despite the wide-spread availability of different flexible falsework systems, the use of timber may be beneficial in some cases. Figure 4 gives an example of a rather heavy structure used for bridge construction (Holzbau-Taschenbuch, Band 1, 1986). There are longitudinal steel beams (or lattice girders), the towers, however, are timber structures. It should be noticed that controlled lowering of heavy falsework is definitely necessary. This structure has to be designed according to accepted principles with particular emphasis on buckling, lateral torsional buckling and overall stability. In many details stresses perpendicular to the grain may be critical.

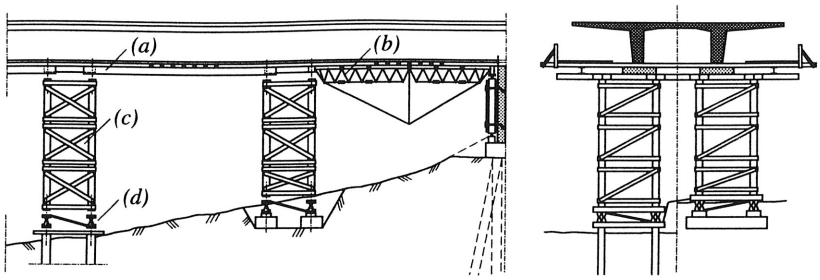

Figure 4 *Heavy falsework used for bridge construction. (a) Steel beam, (b) lattice girder, (c) timber tower, (d) spindle for lowering.*

Figure 5 shows a section of the falsework used in the construction of parts of the Condeep platform, Troll, in the North Sea. The bottom part of the platform consists of several cylindrical cells, each covered by a spherical dome with a diameter of 32 *m*. The structure is formed by 144 curved nailplate girders arranged radially and supported by a compression ring at the center of the dome. The complete structure was prefabricated and lifted into position by a number of cranes. The handling caused an entirely different load situation compared to the weight of the concrete (of a thickness for the regular cells varying between 0,5 and 0,7 *m*, and up to 4,5 *m* in special cases). This rather complex and newly developed nailplate structure was designed and detailed using computer programs (Ringstad, 1993).

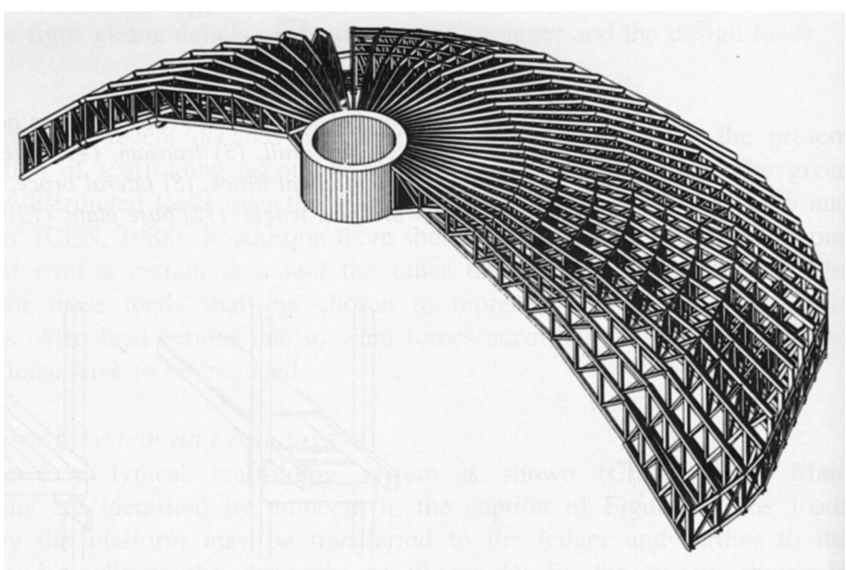

Figure 5 *Section of a nailplate based domelike falsework.*

Concluding remarks

- Even when scaffolding and falsework structures are temporary constructions, they should be designed according to the principles given in EC5.

- Accidents related to temporary structures are often caused by disregarding the overall stability and the necessity of horizontal and vertical bracings.

- Both safe overall erection and disassembly procedures as well as relevant details are essential to ensure safety on site.

References

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CEN (1988), Service and working scaffolds made of prefabricated elements. Materials dimensions design loads and safety requirements. Harmonization Dokument HD1000, Brussels.

Holzbau - Taschenbuch Band 1 (1986). 8. Auflage (in German), Verlag Ernst und Sohn, Berlin. p. 537.

Ringstad, H. (1993), Trekonstruksjoner som forskaling på TROLL-plattformen (in Norwegian), Byggeindustrien no. 1, 1993 p. 60 - 61.