Climbing technology at the edge of the building and for the core during the Taunus Turm construction project in Frankfurt/Main, Germany.

Climbing Systems

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Climbing Systems - The right system for every project

Selection of the appropriate climbing system will result in crucial improvements to high-rise construction workflow. However, not all systems are alike. Investing in a higher-quality climbing system makes sense if it leads to savings of manpower, cost and construction time.

Contemporary architecture is dominated by ever higher buildings and ever more complex geometries. The success of such construction projects depends in large part on successful optimization of the construction process. In the field of high-rise construction, the decision for the appropriate climbing system has a huge impact on time and cost of construction. As a result, diligent operations scheduling is of crucial importance: in order to find the optimal formwork solution, factors such as cycle time, construction method, type of reinforcement and site equipment must be taken into account as early as during the planning phase.

Not all high-rises are alike

High-rises not only differ in terms of their outside appearance or architecture but also in terms of structural design, building materials and construction methods as well. However, many have common features, such as one or more cores built with in-situ concrete for developing systems that ensure accessibility. For this reason, in most cases it makes sense to use a climbing system.

The building industry is increasingly shaped by minimizing cost and time of building. Therefore, it is beneficial to include the formwork supplier as early as possible in the operations scheduling. Even the specifications should take into account current options of formwork technology. It is also extremely important to identify problematic building zones in advance as well. They not only consist of changing wall cross-sections, but also different wall inclinations or intermediate stories with varying heights. They may also be installations weighing several tons that need to be considered. Anything that is not considered in advance will frequently result in subsequent added costs and risks caused by time-consuming improvisations after the fact that often impact safety too.

The market offers many climbing systems that differ in terms of technical function and price. It makes sense to invest in a higher-quality climbing system if it improves construction processes and results in savings of manpower, cost and construction time. Observing cycle times when producing a story plays an important part in staying on schedule. High-rise cores are frequently built in a four- to five-day cycle.

The following pie chart shows how the different activities are typically arranged when building a high-rise core. In addition to forming work, a large percentage of the hours worked is used on reinforcement and mounting parts installation.

Typical example core

![Figure 1](image)

(Figure 1) Selecting the appropriate climbing system may affect scope and distribution of jobs in a way that is material to project success.
Not all climbing formwork systems are alike

The term “climbing formwork” identifies the combination of shaping wall formwork with a load-transferring primary working platform in form of a climbing scaffold or a climbing platform. Anchor parts with load capacity predefined by the manufacturer allow for safely suspending the climbing system on the preceding casting section at any height. Minimum concrete strength must be observed diligently because the climbing formwork is always attached to the most recent wall section.

It is important to carefully check each suspension point to make sure the concrete can absorb the forces introduced - possibly by way of additional reinforcement that might be required. Usually rising and suspended platforms for reinforcing, pouring, operating the climbing system, reworking the concrete and dismantling the suspension points are installed above and below the main working platform.

Climbing formwork is lifted up to the next casting section either by crane or independent of a crane by way of hydraulic cylinders, with and without being guided on the structure. Depending on type of building, climbing systems can also be used at the edge of the slab: for producing facade walls or columns, vertically transporting formwork material, or in the form of a fully enclosed screen system to protect the site crew from falling and weather.

Climbing systems function as kit solutions

The climbing scaffold can be combined with large-area formwork and with framed formwork systems as well. The distinguishing feature of large-area formwork is that it can be adapted to allow for customization with any ground plan in terms of panel size, fresh concrete pressure and number of form-tie points. On the other hand there are framed formwork systems consisting of standard panels in various sizes. They are assembled in accordance with the kit principle and adapted to the shape of the structural element to be created out of concrete.

Mainly when building shafts are a well thought-out formwork design, they may result in saving hours of work due to the often large number of similar casting sections and repetitive operations. Here “thinking of stripping while making plans for forming,” may turn out to be a crucial advantage. Especially on inside corner areas, it is vital to ensure easy separation of formwork from concrete and to create the most spacious stripping distance possible for efficient working conditions. At the same time it is beneficial to keep the number of form-tie points to a minimum. Tie rod systems that can be operated from one side may result in significant time savings.

In general it is important to use durable formwork sheets when producing a large number of casting sections. Generally these are high-quality multiply formwork sheets coated with phenolic resin or plastic. Formwork sheets made of steel are used as well. Changing sheets is a time-consuming operation best avoided or deliberately scheduled in the construction workflow.

In addition to its own weight and that of the formwork, the climbing scaffold must also transfer live and wind loads into the casting section already completed. For this reason, securely anchoring the climbing scaffold is of enormous importance. The climbing system can be lifted as soon as the section poured last has achieved sufficient strength.
Crane-dependent climbing

When using a crane for lifting, it will lift the climbing scaffold and formwork to the next section as one unit. Crane and load capacity must be planned accordingly. Here a distinction is made between systems that are “guided on the building” and those that are “not guided on the building.”

During lifting, climbing formwork not guided on the building are completely detached from the structure and suspended freely from the crane. Even at low wind speeds the area exposed to and resisting wind may lead to problems. The process of lifting individual units creates temporary fall hazard locations that must be secured accordingly. Systems that require cranes for lifting are normally used for buildings up to 20 casting sections.

(Figure 2) The risk of downtimes caused by wind and limitations of crane capacity must be taken into account when using crane-dependent systems not guided on the building.

The advantage of climbing systems guided on the building is that they remain connected to the building during the lifting process as well. The aspect of safety while lifting climbing systems must be considered as early as during formwork planning. Average wind speed rises proportionally to height above ground. In order to reduce the risk of downtimes, systems that can be lifted even at higher wind speeds are used here.

Currently the limit is at 72 km/h wind speed. Steel profiles secured in climbing shoes attached to the structure ensure that the system is guided on the building. The process of lifting individual units by means of a crane creates temporary fall hazard locations that must be secured accordingly.

Crane-independent climbing

Crane-independent climbing systems guided on the building avoid some of the open fall hazard locations because several climbing units are lifted simultaneously. The preferred way of moving these climbing systems is through hydraulics, using portable hydraulic cylinders and hydraulic units. A single hydraulic unit can supply power for several hydraulic cylinders at once. When crane capacity is available, some types are quickly lifted as well by means of a crane.

(Figure 3) Crane-independent climbing systems guided on the building allow for consideration of downtimes due to wind and weather as well as compensation of crane downtime through use of a mobile hydraulic unit.
All-hydraulic drives ensure speed

The principal difference to simple crane-independent climbing systems guided on the building is the all-hydraulic equipment of climbing units. They allow for safely climbing large platform gangs such as all platforms on the outside of a core in a single lifting procedure without open fall hazard locations. Such systems cannot be lifted via crane.

The hydraulic lifting process requires two important steps: In the first step the climbing profiles in the climbing shoes anchored on the building are raised by hydraulic cylinders up to the next section. In the second step the climbing scaffolds are pushed upward along the climbing profiles by the same hydraulic cylinders. This type of climbing formwork is extremely versatile and also allows for climbing inclines, radii and bends. In addition to high-rise cores, these systems are also used with piers and pylons.

Systems with 5 and 10 tons lifting capacity per climbing unit are established in the market.

(Figure 4) Crane-independent climbing systems with all-hydraulic drive as exemplified by the “core formed ahead” construction method, which largely uncouples the construction workflow from wind, weather and crane capacity.

Platform systems with spacious work area

Platform systems are formwork machines geared especially to building high-rise cores. The primary component is an enclosed forming and work platform for safe working conditions and protection from weather even at lofty heights. It can accommodate the entire site equipment consisting of formwork, reinforcement steel for daily work, material container and concrete placing boom for a building core. Long-stroke hydraulic cylinders raise the platform in a single lift to the next casting section without a crane. The formwork is suspended from a girder grille like a curtain for easy forming and stripping. The larger the area of formwork that can be positioned below the pouring and reinforcement platform, the more economical the system. Structural and customer requirements, especially installation of reinforcement or mounting parts, play an important role in this regard.

(Figure 5) Automatic climbing platform systems as exemplified by the “slab and walls cast in one pour” building method uncouple the construction workflow in high-rise cores
from wind, weather and crane capacity as much as possible.

Everything must be in sync

The method of construction is greatly influenced by the building's structural design with corresponding reinforcement layout. Here a distinction is made between the “core formed ahead” and the “slab and walls cast in one pour” construction methods.

Most often subcontractors carry out reinforcement work by the piece. It is important to gear the climbing system to the requirements and in doing so influence the workflow positively. Vertical scaffold systems start off with simple pouring platforms on the formwork. Disadvantage: As soon as the formwork is stripped, these platforms can no longer be used for installing the reinforcement. In contrast, pouring and reinforcement platforms that are independent of the formwork allow for optimal reinforcement installation even during the stripping process. In this way forming work is separated from reinforcement work, thereby allowing for simultaneous work on several levels. To accommodate taller reinforcement bars in advance, several rising reinforcement-platforms can be arranged vertically. In the event of thicker walls and increased degree of reinforcement, planning for reinforcement work to be carried out from two sides makes sense as well.

The higher the building the less economical the concrete installation by way of crane and bucket. As the building height increases so do lifting and sinking times and also the time the crane is tied up. Installation capacity can be increased by using concrete pumps with various types of placement systems and large booms for efficient installation of concrete. Combining the concrete placement system with an automatic climbing system also provides the opportunity for lifting the system without a crane - separately or together with the remaining automatic climbing formwork, as required.

Another important consideration are confounding factors resulting from changed building geometries and related modifications to the formwork and replacement of worn formwork sheets. Work for producing staircases / stair landings must be included too. For this reason it is important to have the foresight to address these issues during formwork planning.

As mentioned initially, a high rise does not consist solely of a core. It also includes facade and floor-slab through to the installation of the facade panels. It is important to consider the synergy here as well.
(Figures 6, 7 and 8) Crane-independent climbing system with all-hydraulic drive and pouring platform on formwork, reinforcement and pouring platform and rising reinforcement platforms.

Conclusion

Depending on the ideas of the customer, there are many different requirements for climbing formwork. Not every climbing system is suitable for every building. Likewise the building height does not immediately determine the best system. Therefore, when developing a formwork concept it is very important to consider the various customer requirements as well as framework conditions related to construction operations from the very beginning. With each and every climbing project the following steps are strongly recommended: close cooperation with the formwork supplier, utilizing his experience and expertise, and an overall economic concept in terms of engineering, construction workflow, and budget to be provided as early as during the project development stage.

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