INTRODUCTION

Usually when we are talking about site layout facilities we refer to essential temporary facilities that are required to be provided during the period of construction in order to assist in the completion of the construction works. Site layout facilities and construction planning usually has a close relationship for some of the major construction activities are highly depended on the provision of these facilities in order to have the works completed effectively, efficiently and according to a complicated schedule which in most cases is set under a well coordinated manner. In a general sense, these facilities include:

a) Items or facilities that are essential and required for the carrying out of the construction works such as craneage, site transportation equipments, falsework as temporary support or to facilitate various storage purposes, or the allocation of temporary work spaces for work vehicles, workshops, sub-contractor yards and other essential site activities.

b) Items or facilities that are required for the well being, convenience or safety of workers such as washing/changing rooms, shelter or rest facilities for workers, canteen, access to work fronts, or other safety provisions.

Consideration between Site Layout Facilities, Provision of Work Equipments and Construction Planning for Extremely Large and Complicated Construction Projects

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ABSTRACT:
The effectiveness in site layout and construction planning for extremely large-scale and complicated construction projects not only affects productivity and cost, it also controls whether a project can be handled and completed in a practical, safe, orderly, efficient and engineering feasible manner.

Projects qualified to be extremely large and complicated can be in a variety of forms. Take for examples in Hong Kong’s situation. Construction cost of projects sometimes exceeds billions of dollars. Site covers more than a few hectares of land with building areas in term of hundred thousands square meters. Or, projects sometimes involve the construction of super high-rise buildings with more that 60 or 70 storeys in height. This kind of building development projects, very often, consists of a number of annexed facilities such as a very deep basement, or a podium with very large interior space and long-span elements. Special structures like buildings constructed in structural steel or in composite manner. Some projects are located within very congested urban environment, or located in close proximity to steep slope, or adjacent to sensitive facilities like underground tunnels. In case of civil engineering projects, sometimes they also involve special provisions, diversion and interfacing arrangement to very busy servicing traffic and other urban facilities.

This paper will identify various types of construction cases qualified to be of extremely large and complicated nature under the built environment of Hong Kong. The paper will also illustrate how builders solve such problems using innovative methods. Relevant brief case examples from civil engineering works in particular for transportation facilities will also be referred in order to substantiate the explanation of the subject matter.

1 INTRODUCTION

Usually when we are talking about site layout facilities we refer to essential temporary facilities that are required to be provided during the period of construction in order to assist in the completion of the construction works. Site layout facilities and construction planning usually has a close relationship for some of the major construction activities are highly depended on the provision of these facilities in order to have the works completed effectively, efficiently and according to a complicated schedule which in most cases is set under a well coordinated manner. In a general sense, these facilities include:
c) Items or facilities that are required for the overall site logistics, operation and management such as site entrance provision, site office, meeting or conference areas, supply and routing of essential services, site laboratory, or other security provisions.

d) Items that are statutory required for the carrying of the construction works such as fencing or hoarding, signage, wheel washing facility; equipment for waste disposal, water treatment, noise and dust control, or arrangement for temporary traffic diversion etc.

These facilities usually have specific work targets or operation nature, however, they still have the following characteristics in common:

a) Essential or not easy to be substituted for the carrying out of the specific construction works,
b) Fairly temporary in nature,
c) The positioning of these facilities often affects the efficiency of the construction in particular when they are not properly located,
d) The positioning of the facilities often occupy significant work spaces and may affect the regular progress of other major activities,
e) Often required to be relocated to meet the advancement of works or progress of construction,
f) Some of these facilities may have very important operational, structural or safety concerns,
g) The provision, installation and maintenance of these facilities can be quite timely and costly thus the providing, relocating, maintaining or dismantling of these facilities should be planned in a very careful manner in order not to interrupted with the master planning of the construction works.

2 INTRODUCTION PROVISION OF SITE LAYOUT FACILITIES

Provision of site layout facilities can be further classified according to stages of construction and types of project. Below are some of the examples of these classifications and provisions.

A. Provision of site layout facilities according to stages of construction

a) At the commencement of the construction project

Site layout facilities to be set-up at this stage usually include provisions that must be provided before the effective carrying out of other major construction works, or other work items that are required by the concerning statutory requirements. These facilities include, for example, the site fencing, supply and routing of water, surface drainage system, forming and arrangement of access routing, setting up of site offices, arrangement for the delivery and positioning of the essential work equipments, and other provisions as required by relevant statutory requirements.

b) At the peak period of the construction project when the permanent structural works are to be carried out.

Facilities to be set-up at this stage are more specific for the carrying out of particular works, some of them are more temporary in nature. Examples of these facilities include the tower crane, workers lift, material hoist, access provision to working fronts, work scaffold, temporary platform, falsework or additional support to the required structures, and other equipments or mounting up which are required for the external works of the building such as a power wincher system for the installation of curtain wall units which is operated on a temporarily provided track rail.

c) At the final stage of the project when the touching up, finishing works or other handing over arrangement are to be carried out.

At this stage of construction majority of the site layout facilities are required to dismantle and remove from site. For some particular equipments or facilities, some kind of additional provisions may be required to assist in the dismantling of them. For example, a winching machine and a lifting rod may be erected and set on the roof level to help the dismantling of a tower crane and lowering its components down to the ground level for removal. And of course, provision for the touching up of the disturbed areas after the dismantling and removal of the facilities is also required.

B. Provision of major site layout facilities according to types of construction

Site layout facilities is relatively a general term for the setting up and operation of a construction site for the nature, scale and type of works diversify greatly from project to project. Situation for building projects is relative much simpler when compare to civil projects. Below are the highlights of some of their feature according to the types of construction.

a) Building projects involve the construction of super high-rise tower/s in a relatively confined site. The site layout facilities for this kind of projects, for example, include:
(i) Facilities and work spaces for the delivery of construction materials or placing of concrete,
(ii) tower crane, mainly to assist work activities on floor-top work front,

Photo 1 – Tower crane used in high-rise building construction projects can be mounted in a number of ways. This photo shows a climbing crane used in the construction of a steel frame building.

(iii) hoisting equipment (for delivery of materials or components to structurally completed floors),
(iv) handling spaces for building materials and semi-completed components including precast items, (Photo 2)

Photo 2 – Storage of material can be very difficult for single tower type high-rise building. This photo shows the temporary storing of semi-prefabricated steel components on partially completed steel floor beams.

(v) loading platform on intermediate floors for the removal of materials such as formwork panels or propping components to other floors,
(vi) temporary workers hoist or lift,
(vii) safety provisions in particular setting up to prevent workers or materials falling from height etc.

b) Large-sized building projects in particular with very large site area or involves works on site with complicated shape or layout. This includes, for example, deep and large-scale excavation, work adjacent to slope or sensitive structures either at grade or underground. The involved facilities for this kind of project, for example, include:

Photo 3 – Delivery and storage of precast components for congested site can be very difficult in particular when the sequence of installation is taken into consideration.

Photo 4 – Super-sized building site (the International Finance Centre) with major excavation for basement construction and other associated work activities in various locations carried out at the same time.
(i) Similar to site layout facilities as described in the above but with the addition of some other facilities such as access road and equipments for site internal transportation.

(ii) Set-up for temporary shoring works for the protection of deep excavation, slope cutting or sensitive structure.

(iii) Involve the construction of a large-size and deep basement using sophisticated method such as in top-down or other hybrid approach.

(iv) Handling or storage area in particular for intermediate materials handling purposes.

(v) Waste water treatment facilities due to the collection of surface or construction waste water from the large area of site.

(vi) Other environmental protection related facilities such as dust screen, catch fan or noise barrier.

(c) Various types of large-scale and complicated civil projects. Examples of these types of projects include site formation, slope treatment, marine works, water supply or drainage works, highways projects, railway construction, tunnel works, bridge construction, and other infrastructure development projects.

Site layout provisions for civil work projects are often in a highly dynamic nature due to the involved works are mainly in a horizontally-spread layout without a lot of tall and independent structures. Equipments or facilities involved are usually different for various kinds of civil works but in general they are very heavy duty in nature for the requirement to handle huge amount of materials or very heavy components, or for the supporting of very large loading. Very large operating space and additional equipments are normally required for the erection, maneuvering, operation and dismantling of these facilities. Below are some of the examples of these facilities that are used in civil engineering works:

(i) **Temporary accesses for work machines or manual workers.** These accesses can be erected over water, over large area of undulated surfaces, down to deep excavation pits, climb to great height or span between
very tall structures (e.g. bridge towers), or provide access to very steep slope.

Photo 8 – The construction of a 1.2 km-long temporary ramp above sea surface to facilitate the construction of the bridge piers for an elevated expressway.

Photo 9 – Provision of a steel ramp from the portal area down into a tunnel constructed using drill-and-blast method.

(ii) Equipments and provisions for the transportation and lifting of bulky or very heavy materials such as excavated spoil materials, structural steel, precast or semi-completed components. These materials sometimes can weigh up to hundreds of tons. The involved equipments, for example, can be various types of work machines for earthwork, conveyor systems, cranes, launching equipment, portal frame, hydraulic trolley or jack systems etc. Sometimes, such provisions may even include the setting up of temporary unloading facilities such as a pier for marine works or for the delivery of large and heavy materials transported to site by sea. And of course, an appropriate access routing should also be provided for the working and handling of these equipments.

(iii) Falsework system for various purposes such as support for temporary work platform for machine stationing, for material handling and storage, provision of additional work spaces (elevated or suspended), for the support of long-span reinforced concrete structure which is constructed in situ manner, support for a working platform over an open-cut basement excavation pit, or as support to freshly concreted structure preparing for the temporary placing of additional loadings etc.

Photo 10 – Typical falsework arrangement erected for the support of a pier head for the construction of a section of viaduct. Note that part of the system is erected over a section of water channel.

(iv) Site layout and equipments for large scale earthworks, site formation or foundation works. A large number of very large work machines such as excavating machines, graders, rock crushing machines, dumper trucks, conveyor system, drilling equipments, piling rack or foundation equipments for large diameter piles are involved in these kind of projects. These equipments are often required to work in difficult typographic condition where access problem for both delivery of the machine or the removal of excavated spoil away from the work spot always exist. They will be stationed in one location within a short period and required to be removed at the earliest time when the work has been completed for the onward progress of the other works.
(v) **Equipments for specialized construction works** such as launching gantry for the construction of viaduct or elevated bridges, tunnel boring equipments including the tunnel boring machine (TBM), traveling formwork systems or equipments for tensioning works etc. These equipments have a lot of common features. They are usually very large sized and in very heavy weight. They require very long time and large working space to erect, place to the required location to commence work, or require additional equipments to erect them or when they are to be dismantled.

(vi) **Provision for diversion works** in particular to traffic or other major services located both above or underground. The involvement of this kind of works usually contains a number of temporary provisions such as the temporary closure of some existing facilities, providing of the temporary replacing facilities, coordinate with the related agents for the diversion works, controlling and monitoring of the facilities throughout the process, or to reinstate the items to meet the future conditions etc. The said diversion works may be carried out on ground surface, underground or even over water. Typical examples such as the diversion of box-culvert (large-size underground water discharge system) in reclamation projects, or to construct a section of railway tunnel under existing busy road surface, can be often found in civil work in the built-up area of a city.
3 CONCERNS AND RELATIONSHIP OF SITE LAYOUT, CONSTRUCTION FACILITIES AND CONSTRUCTION PLANNING

From the contractual point of view, site layout facilities and other construction related logistic support is very difficult to be accurately predicted or priced before the commencement of a project. However, the reasonable catering and costing allowance of such work items will practically dominate the success or profitability of a project. Construction planning in reality can hardly be worked out using any programming software not because of the imperfection of these tools. The unpredictability mainly comes from the highly dynamic situation, existence of numerous work variables as well as the involvement of complicated human factors in such project. Summarized in below are some of the common scenarios that show these concerns and relationship.

A. Require additional time in the setting up, maintenance, relocating and dismantling the facilities, as well as the touching up of the related areas after their removal.

Some equipments may need a very long time to have it set up, tuned, tested and commissioned before it can be put into actual operation. Routine maintenance is also essential to ensure they can work effectively and safely. Sophisticated access provision is also required for the placing or final removing of the equipments that may introduce large amount of additional cost input. Typical situation can be found in, for examples, tunneling project using TBM, construction of elevated bridges using precast segments erected by launching gantry, or the hoisting of extremely large and heavy prefabricated component like sections of long-span trusses onto the roof.

B. Require additional resources and handling arrangement in the setting up of the site layout facilities, equipments or other associated works.

Besides requiring a long period of time to set and erect, some layout facilities need much additional equipments or facilities to have them set up. Examples such as the forming of a series of large diameter bored piles for marine works, in which temporary access ramp up to a few hundred meters long and supported on temporary marine piles and steel deck, has to be provided for the purpose.

C. Require additional working space for the smooth operation of the installed facilities.

Projects such as large-scale site formation, slope foundation or tunnel works require huge and sophisticated equipments for the carrying out of the job. Very large working space, sometime on very
difficult ground conditions like on a steep slope, sides of a servicing highway, or areas outside the boundary of the site that belong to other third parties, is required for the setting up and operation of the installed facilities. Very often, this addition space can only be provided under very carefully planned and coordinated manner, or even involve an application and approval process to various agents or parties. Sometimes these works may also affect the normal progress of other major work activities that require extra or alternative planning to coordinate them with the basic works within the scope of the contract.

D. The provisions of many of the site layout facilities are having complicated cost implication.

This is obvious for the additional input in the provision of the required facilities usually involve expensive equipments, cost of installation, maintenance and removal cost, or the participation of sub-contractors and other managerial input. Careful cost estimate and analysis in appropriate stages can in most cases help to minimize the cost effect of such extra work to a reasonable and controllable level.

E. Very expensive equipments may be involved that very careful resource planning should be introduced.

Expensive equipments are often required for the carrying out of specific works in particular for civil engineering projects. Whether the equipments are to be transferred from a soon completing project, to buy a new one, to hire them from other available sources or to be provided by a sub-contractor, is a matter of resource planning consideration that may affect the master planning and profitability of the project.

F. Some components of work or construction operations may require a very long lead time that advanced planning and coordination is essential before works can be carried out on time.

Examples for these works include large and complicated precast or prefabricated components, or sophisticated equipments such as a bridge launching gantry or large-diameter tunnel boring machine. Sometimes for building works such as prefabricated construction using structural steel or large amount of precast components, production and installation of the curtain wall. These works often require a long lead time in the design, sub-contracting, internal decision, prefabrication, quality control, testing and commission, coordination (including approval) and transportation of the items before they can be delivered to site for the actual operation.

Photo 18 – A temporary service shaft formed in the midway of a 3.5km-long tunnel as emergency access as well as for the transportation of working plants and materials.

Photo 19 – Immersed tubes for a harbor crossing tunnel were constructed in a dry-dock which takes 4 months to complete. The process repeated 3 times to provide 12 tubes for the final tunnel alignment. The completed tubes would then be towed to the tunnel position for sinking into the pre-dredged seabed. Contingency plan to cater for any accident happen during the entire work process was an impression issue for the project.

G. Construction works are carried out in various phases according to the construction planning or other constraints of site.

Large-sized projects often cannot carry out the whole contract works at the same time due to the very large scale of works as well as other constraints such as considerations in the supply of resources, limited access; or even forming part of the master planning to provide additional work fronts to allow major activities to be done in parallel.
A commercial development project located in congested built-up area with a 4-level basement. To make the construction more time-effective, the basement was sub-divided into 2 phases with the first phase on the office tower side. The remaining phase will be done at the same time with the construction of the 42-storey office tower.

Owing to the locating of shallow rock-head on one side of site, the construction of this semi-basement for a commercial complex introduced an additional phase in the master planning program (left portion in photo) to avoid interruption to the progress of the main structure.

Sometimes the construction plan may require part of the structures to be completed in an advanced or deferred manner for various purposes, such as to provide working space for the moving in or removal of large-sized machines or components, to provide access for the operation of some major construction activities that works in parallel with the main structure, or to allow some delayed or second-fix works to catch up. This kind of arrangement may seriously affect a pre-arranged site layout plan or master planning of a project and should be considered carefully in the overall master programme well in advance.

A 15m slot on the main structure of the Hong Kong Convention and Exhibition Centre was cast in a delayed stage to allow for the moving in of a series of 80m-long prefabricated roof truss sections. Note also the temporary loading pier on the seawall for the delivery of the truss sections.

Sometimes a site may be handed over to contractor to commence work in separated stages or required to complete the works in various phases for handing back to the client.

Under this kind of project situation, beside the resource planning or contractual consideration issues, alternative or teething arrangement in the site layout and the related provisions will obviously be much complicated and sometimes may affect the overall planning of the construction. In some extreme circumstances, another main contractor may also be working at the same time within the site that make the situation even complicated.

Possible occurrence of unforeseeable risks.

Numerous variable factors co-exist with large-size and complicated construction projects. One common characteristic is that these projects often involve a great number of work parties both in-house or within the contract. Sometimes the extent of works may even extend across countries (e.g. prefabricate a 400-ton steel roof truss in Philippine and send it to China for final touch-up and transport back to Hong Kong for assembly). The occurrence of risk is not so uncommon for the unimaginable involvement of huge amount of variable factors. These factors leading to risks may come from contractual, managerial or subcontractors matters; engineering, technical, financial, resources issues; the occurrence of work accidents, or even come from other natural or social matters such as extreme inclement weather, industrial strike or other human errors. To minimize the loss coming from these risks, thorough risk management in all aspects and a feasible reaction
plan should be made practically in the early stage of the project.

K. Encountering of significant technical or engineering difficulties

In some project situations in particular those involve geo-technical elements such as slope work, basement construction or even some marine works, although stringent investigation has been carried out beforehand, very difficult technical or engineering problems may still appear during the course of work. The appearance of such problem may have very short notice time and require a great number of additional resources or planning input to have them rectified. And of course, the site layout and other relevant provisions will be greatly interrupted when such situations occur.

4 SOLUTIONS TO ENSURE THE EFFECTIVE RUNNING OF A PROJECT

There is no single and right-away solution to solve difficult or multi-issue problems. Effective solutions depend on a number of things (including luck and fortune). Highlight in below are some factors that almost a thumb-rule leading to successful site practice.

A. Master planning should be done in well advance covering the detail construction plan, method statements, work scheduling, resources planning or budgeting factors. In the information technology age, such planning can be very sophisticated that sometimes involved a huge amount of data collection, statistical analysis, laboratory works, computer modeling, alternative design or the alike. Inaccurate planning may result to the generation of more variables and risks.

B. Provide adequate provisions for all aspects of work within the contract budget for the support of the project. A well interest-balance between the cost controller and the frontline executives should be maintained at all time. This is not easy to achieve for the provision for most of the site layout facilities or production equipments are fairly expensive.

C. Ensure detail understanding and produce a high-quality construction plan for the project based on contract specification, drawing details and other contract documents.

D. Develop closer communication means between various contract parties and all nominated subcontractors or in-house sub-contractors to ensure work can be carried out swiftly, correctly and in a harmony manner without absolute conflict and misunderstanding.

E. Input sufficient manpower for the control and management of all works. A good and workable master plan does not work alone without the providing of sufficient manpower. The reason is simple for the carrying out of the construction works, in particular for those highly dynamic and sophisticated activities like the site layout provisions and all other major production activities, it requires a great number of frontline staff to supervise, monitor, participate and coordinate in order to have the works being done properly.

F. Develop an effective and high quality management system. In a general sense, management involves five fundamental elements including organization, planning, coordination, control and decision. These elements are universal for all kinds of construction works. The reasons and philosophy how a good management system brings to site layout planning and the related construction work implementation is understandable.

G. Careful monitoring of all the significant works including both the frontline activities, communication and contractual matters. Monitoring of work is an assurance to make works being carried out in the as-planned manner as well as to avoid the possible occurrence of unpredictable risk during the course of work. Monitoring of work should be done in the right time, achieve the right observation, made the correct judgment and be able to initiate the appropriate response action. This is particularly important for highly dynamic construction works.

5 CONCLUSION

Experience tells the industry that there is no fix rule or extremely powerful software in the planning of site layout, construction operations and the related issues. There are only basic principles. There are numerous options, alternative schemes, action agenda, management strategy or contingency plans to meet the actual requirements before or during the course of a construction project. How to make the correct observation, identify the problems and arrive at the right decision is the main key to achieve the best solution. A well-experienced and practical construction executive or work team supported by a reasonable resources and management back up should be the best solution to all problems. This paper serves only to highlight some of the related factors with simple case examples so that the complication or uncountable variables and options in the running of large-size construction projects may be better comprehended.