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Main Theme B

Engineering and Construction Management

Gestion du projet et de la construction

Management von Planung und Ausführung

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SUMMARY
By means of this Introductory Report, authors of building practice works are invited to relate practical transferable experience which they have gathered in the fields of Engineering and Construction Management. The author offers his contribution in presenting all essential elements of Construction Management and demonstrating their correlativeness. Differentiation is made between the systems and their actual application and supplementation.

RESUME
Ce rapport introductif est une invitation aux spécialistes des grands chantiers à faire part de leurs expériences relatives à la gestion du projet et de la construction. L'auteur présente les éléments essentiels de la gestion de la construction ainsi que leur interdépendance. Différents systèmes sont présentés, de même que leurs applications et développements.

ZUSAMMENFASSUNG
Mit diesem Einführungsbericht werden Autoren aus der internationalen Baupraxis eingeladen, aus ihren übertragbaren Erfahrungen auf dem Gebiete des Engineering und Construction Managements zu berichten. Als Hilfestellung führt der Author alle wesentlichen Teilgebiete des Construction Managements auf und bringt sie in einen Zusammenhang. Es wird zwischen den Systemen unterschieden und ihrer Fortschreibung und Handhabung.

0. ENGINEERING AND CONSTRUCTION MANAGEMENT

Management is comprising of all procedures which are necessary for the purpose of methodically planning and organising the execution of work activities and to bring the work to a satisfactory conclusion within the scheduled parameters. Therefore management is important both for engineering schemes as well as for executing a construction project. For this purpose management techniques based on "systems" [1] can be applied. Tender estimates, contract packages, or network programmes etc. are examples of a "system". They require to be continuously adapted to changing situations of which the execution of a construction activity is a typical example. The system has to penetrate the problem in detail without becoming too heavy handed nor lacking flexibility. The system also has to contain control standards whereby one may ascertain that the course being persued is the correct one. The system should also afford suggestions as to the corrections to be adopted in given situations. In all events individual systems require to be compatible with each other and must be integrateable. It follows therefore that management is the establishment of such systems and their continuous application and adaptation.

The design of a building may also be regarded upon as a system, but it is emphasized however that this is not a dynamic system. Once established the design will be adhered to in its original form. Management systems however are in most instances considered to be dynamic systems. They must be capable of adjusting themselves to continually changing conditions in order to attain the overall objective in spite of all disturbances which may arise.

As engineering and construction activities are partly dependent upon human intervention it is difficult to predict, within a dynamic system, the negative and positive impact of the human factor. Fortunately the laws of material do not apply to man. Nevertheless the design engineer and the practitioner on site are faced with the difficulty of assessing the human factor and making allowance of same within a methodical application of a system. For the design engineer the gap between the anticipated and the actual result is too wide, while for the site man it often appears that theoretical aspects play too great a role. Therefore it is the practitioner who is specifically called upon by this introductory report to make known his experience regarding construction management methods in Session B. Only a brief allusion should be made to the project itself because the main objective is that the participants of Session B should benefit from special experiences and methods of construction management. Management can be dealt with within the fields of both engineering and construction. The application within the organisation of a construction company is of particular interest. This introductory report therefore is designed to motivate construction practice authors and to afford them introductory guidance.

1. ENGINEERING MANAGEMENT

The design of a project comprises amongst others, major organisation problems and it is submitted that these may be easilier solutioned by applying management techniques. Within this chapter specific emphasis is made to the ever increasing problem of turn-key contracts. Figure 1 hereafter compares the standard construction contract to the turn-key contract. Although the turn-key contract offers advantages such as comprehensive responsibility and a gain of time, major problems may be encountered. For example the period in advance during the phase of planning, in respect to the corresponding construction design work, is very short. It is essential in order to avoid major problems during the construction phase that planned procedures be adhered to. This is particulary true in regard to approval procedures and to the time allocated to those participating in the planning phase. The client himself if he takes an active part in the planning phase must be able and willing to adapt himself to the required tempo.

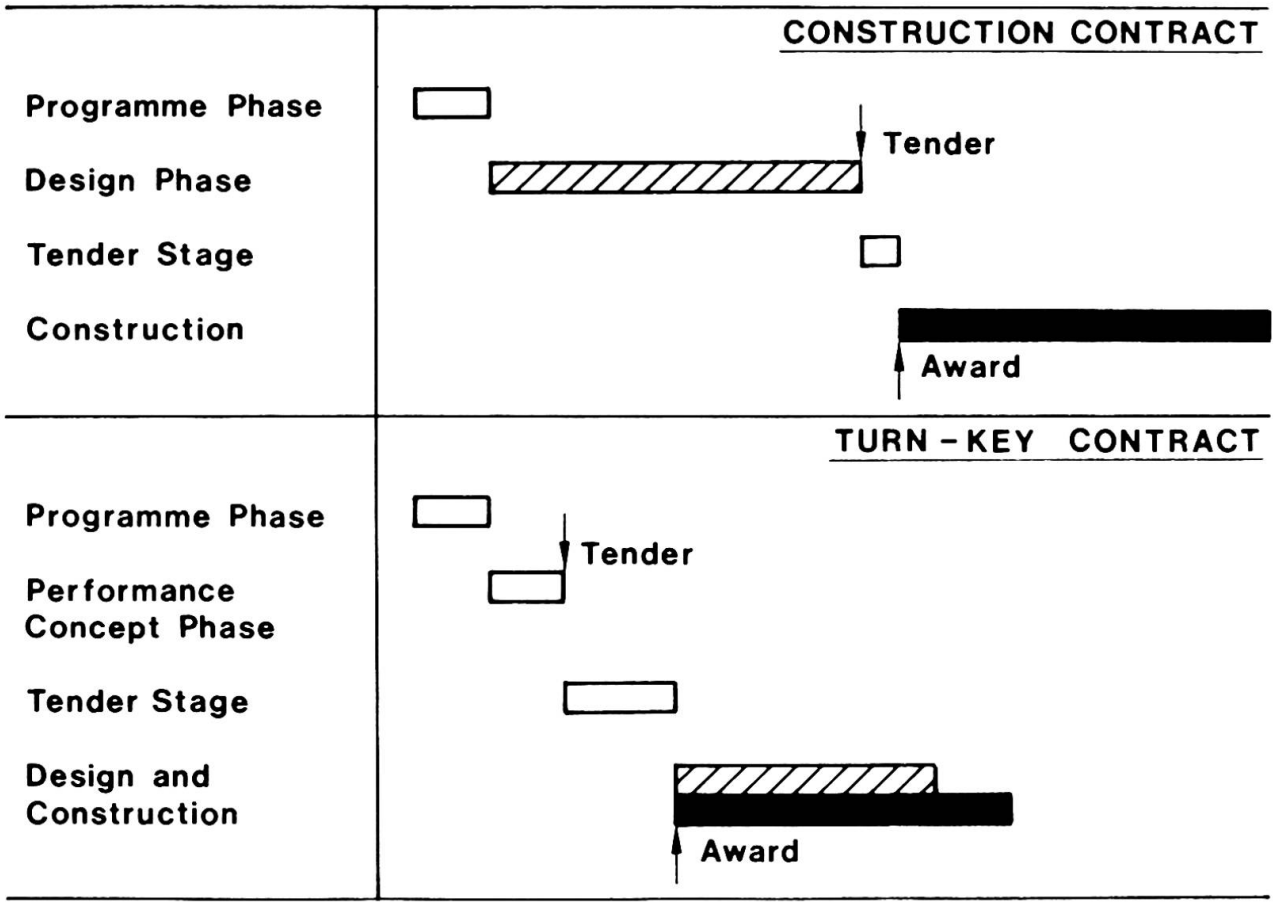

Fig. 1 Comparison of Construction and Turn-Key Contracts

2. CONSTRUCTION MANAGEMENT

More and more it is becoming obvious to what degree the costs of a construction project are influenced by the methods and procedures foreseen for executing the works. Due to the progress of technology we are compelled to direct our attention towards problems of site organization and process engineering. It is only since the latter years that these problems have been considered and investigated into in a methodical and scientific manner. The results gained from this research work will in the near future have a considerable impact on the design, the selection of construction procedures, the drafting of construction contracts and the cooperation of all participants in the construction market.

In view of this rapid developing phase of construction management it will be very interesting to present to a large public forum like the 12th Congress of IABSE in Vancouver the experience gained through the practical application of different methods for specific elements of construction management.

The following Fig. 2 illustrates the structure of the Management Organization System

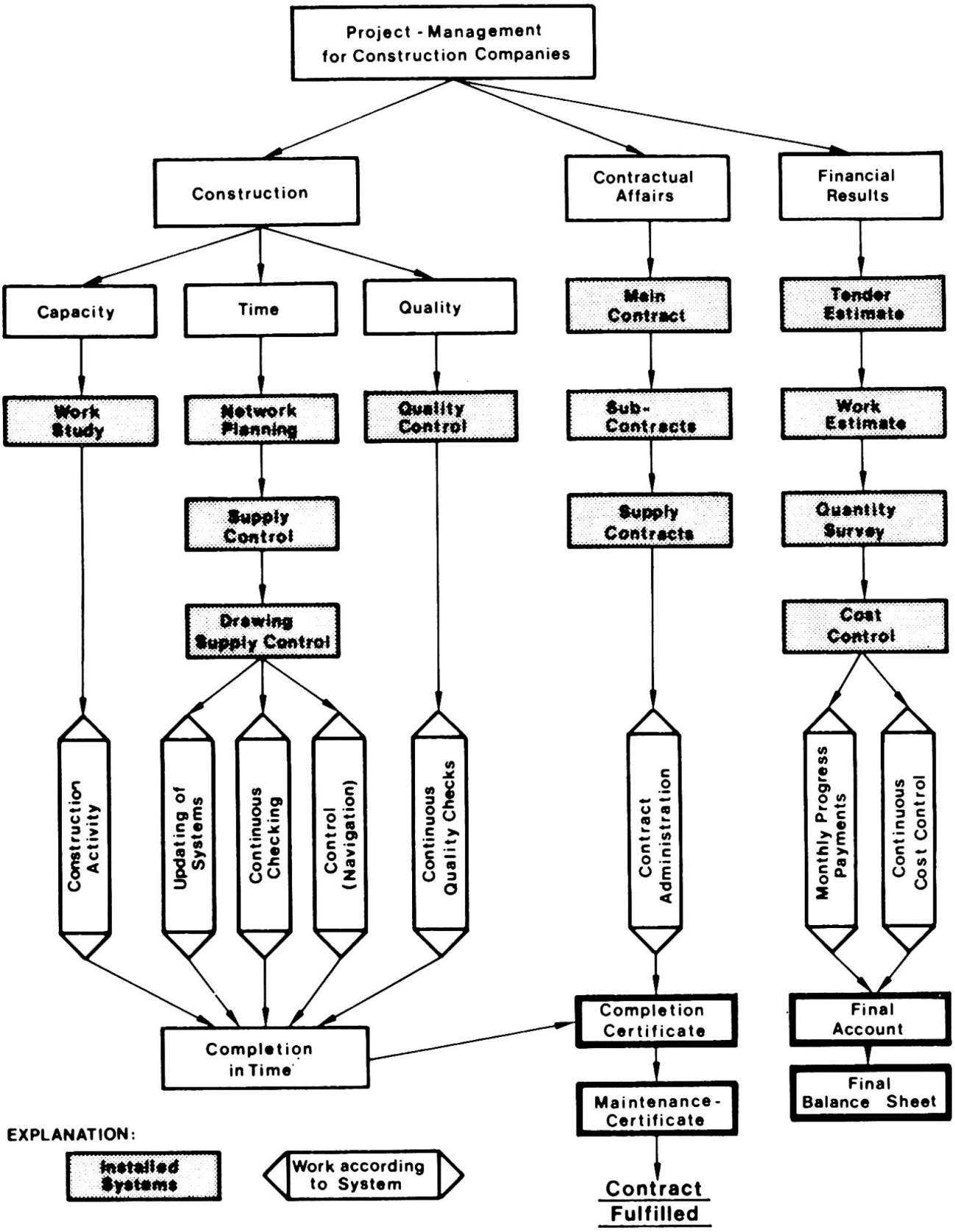

Fig. 2 Management Organization System

Fig. 2 shows the various elements of Construction Management
- Construction
- Contractual Affairs
- Financial Results

From each main element is originating one or several systems. Within each system (shaded box areas) the work to be executed for certain projects is structured, comprehended, distributed according to procedures and quantified. The vertical boxes coming next display the various steps and measures, which are to be taken during the construction phase, to ensure that the project will be completed in due time, according to the prescribed quality, and within an acceptable cost frame. In Session B we shall learn of the experience gained in practice with the various systems together with their application and continuous supplementation. The reciprocal action between the individual systems is also of importance. The interdependency is to be demonstrated between a partial performance, the required resources, the time allocated, the required quality, the provisions and obligations stipulated in the construction contract together with the cost of this part of the performance.

It is submitted that a workable system has to be flexible. The possibility should be available to parry both internal and external disturbances before they cause a domino effect to the whole construction site.

2.1 Capacity

To all partial tasks, resources are required to be allocated. These resources consist of various combinations of equipment and work forces. The efficiency of these performance groups is influenced by the human factor either positively or negatively.

2.1.1 Work Scheduling

In the system of work scheduling all the operative steps and their corresponding capacities are established. This implies that all construction work is theoretically anticipated. From the work scheduling is developed the strategic concept of the construction execution. This enables the establishment of equipment lists, the allocation of work forces, capacity calculations and the design of the site installations. The quality and thoroughness of the work scheduling is often decisive for the financial result towards the end of the construction work.

2.1.2 Construction Activity

The resources defined within the work scheduling are mobilized following the tactical requirements. The construction work is undertaken and the execution must be continuously rescheduled in order to make allowance for both internal and external disturbances to the planned execution. These disturbances have to be considered and adaptations made in conformity with other requirements of the Construction Management system. This is to ensure that the works are completed as planned, at the anticipated cost level, not withstanding the disturbances.

2.2 Execution in Time

Major construction projects often include long-term activities far off from the site. These require to be synchronized in such a manner that construction processes will not be hampered by difficulties with procurement and supply. If disturbances with supplies arise they must be neutralized immediately.

2.2.1 Network Planning

For process planning of construction activities a number of graphic and computer aided

devices are available which allow the individual activities to be interconnected. It is a matter of controversy whether such systems, such as network planning, should combine large numbers of activities in a close woven network or whether preference should be given to a less denser network which offers a wider range of possibilities, when considering the daily routine of construction processing. The presentation of such a network is also a matter of differing opinions. Practitioners who are concerned with construction supervision advocate for networks based on visual arrows which are simple to comprehend.

Construction firms however generally prefer to represent the individual activities as a node. The node serves as a description depicting all characteristic elements of an activity such as time, equipment, work force and budget. Another factor in favour of the node network is its adaptability to computer techniques. It would be of interest to discuss these matters in Session B.

2.2.2 Supply Control

Disturbances to logistics such as the supply to the site of material, equipment and spare parts can lead to an economical disaster. It is not sufficient only to rely upon the contractual obligations of subcontractors and suppliers. The general contractor should develop a specific supply system connected to his general network planning. Thus deliveries, acceptances and timely completion may be scheduled, controlled and navigated in a satisfactory manner within the site network planning. Past experience has shown that a supply control based on the site network planning can considerably improve the monetary result of the site.

2.2.3 Drawing Supply Control

The late delivery of drawings is one of the most fatal events which a construction site may experience. Decisions may be made too late and drawings will not be compared with each other with regard to unmasking potential discrepancies. Approvals would also be given with delay. Therefore it is of paramount importance that a drawing supply control system is established which incorporates all disciplines participating in the project. The control system should be specifically provided for within the construction contract. The system should be conceived to allow timely and unbureaucratic controls, warnings and also the premature acceleration of particular matters.

2.2.4 Updating the Systems

The site network planning, supply control and drawing supply control require to be updated at reasonably brief intervals during the complete construction period and adaptations made following the progress of work. The scheduled completion date however should not be affected by these updating measures. The float times contained in the three networks are to be utilized as a means of minimizing the costs of those participating in the project. These three systems may also give warnings of eventual delayed performance of third parties. Quite often the client's or the engineer's shortfallings are the cause of disturbances. When this is the case the control systems assist in upholding the validity of a possible claim. Clients and courts of arbitration often require such detailed proof of causes and effects.

The primary function however of the three systems is to allow the scheduled activities such as supplies, performances and measurements to be adapted to the prevailing conditions of execution. Acceleration measures may also be adopted via contract administration while they are still possible or prior to them occasioning major costs. Directing and controlling the various intermediate steps and phases is also known as "navigation" in view of its similarity to the organization of work on bord a ship between the captain on his bridge responsible for bringing the ship to port and his navigator assisting him with all his electronic devices. A modern construction site requires also to

be correctly navigated by means of early warning systems and corrections to the planned course. It would be too much to expect a construction manager to do all that is necessary on his own.

2.3 Quality

Exemplary construction performances may sometimes result in providing an inferior quality. It is becoming more and more a controversial question, especially where turn-key projects are concerned, as to which standard of quality is actually required. It is noteworthy to underline that the construction cost of a turn-key project has in certain cases practically doubled. Therefore within the system of quality control one has to differenciate between quality assurance and quality control.

2.3.1 Quality Assurance

Within the system of quality assurance a uniform quality framework containing no contradictions is established. The nesessary standards require to be determined.

2.3.2 Quality Control

Within the system of quality control the appropriate tests together with their frequence and statistical evaluation require to be ascertained. Reflexive control by the general contractor is becoming more and more the rule in lieu of the exception.

2.4 Contractual Affairs

A popular slogan intimates that the art of construction is the interpretation of the contract. In no other industry are individual contracts especially drawn up for the purpose of governing a specific project. It is to be understood that all the various conditions and descriptions provided for by the contract have meanings of considerable monetary importance. A bill of quantities containing contradictions or shortfallings may result to extensive expensive contention. A general contractor performs within a system comprising of the construction contract, the various subcontracts and the supply contracts. This system should be watertight, but in practice however this is not always the case. In the event of contradictions and shortfallings they invariably have to be supported by the general contractor.

2.4.1 Main Contract

Opinions differ as to whether a main contract should be drafted in detail or left relatively open. A further subject for discussion is concerning whether bills of quantities should be subdivided into numerous individual items or whether they should be drawn up in a summarized form. Concerning turn-key contracts the extent of the contractor's obligations arising from the design must be determined. An unequivocal price may at a late stage of execution be conflicting with the other parties' conceptions as to the suitability or extent of the required undertakings and their corresponding quality. Turn-key contracts are especially favoured by various developing countries. If a deficient performance concept is experienced in such a contract this will result in a major controversy.

2.4.2 Subcontracts

Subcontractors, especially those who provide sophisticated installations, are generally located in industrialized countries. They are required to fulfill the obligations of the main contract without deficiencies or shortfallings but quiet often this is not achieved. Furthermore practitioners do not always realise nor understand the difference between "subcontractors to be approved" and "nominated subcontractors". In the case of nominated subcontractors these are decided upon and selected by the client often with the help of his

consultants. The client also decides upon the performance to be fulfilled together with the price and any other relevant matter. This nominated subcontractor however remains responsible towards the main contractor. In the case of "subcontractor to be approved", the selection, the performance and the price together with any other matter remain the full responsibility of the contractor without any restrictions. The client retains however the right and the possibility to exclude a proposed subcontractor.

2.4.3 Supply Contracts

The initial impression and understanding of certain main contractors is that in the case of supplies by third parties they will remain free from eventual problems. In practice however this is most certainly not the case. Other than the suitability of the supply itself problems may arise concerning who is responsible for the various modes of transportation. Also upon delivery on site who is responsible for defective or damaged goods. It is suggested that it might be preferable to abandon the monitary advantage resulting from separating delivery and performance and to favour a supply, ship and install contract providing fully comprehensive responsibility up to the final acceptance of the installation.

2.4.4 Contract Administration

In a general manner construction sites produce mountains of correspondence. Meetings are held and minutes established together with memorandums, telexes and incoming and outgoing letters. The engineer gives written or verbal instructions which are often subsequently modified by his representative. The contract drawings contain ambiguities and discrepancies and the contract documents as such often contain the roots of possible contention. A general ignorance and misunderstanding in regard to the duties and obligations agreed upon prepare the way to possible dissension. The remedy which enables one to overcome these difficulties, it is suggested, is "contract administration".

Contract administration properly established and systematically applied allows the contractor to control and to collate all the technical and contractual correspondence received from or to be sent to other parties. It is underlined that contract administration is isolated from the strain and responsibility of the site staff currently occupied with the execution of the works. As construction is synonymous to contract interpretation, the required link with contract administration is obvious. Furthermore the required standards of the work schedule together with network planning and quality control must also be enforceable via this system.

2.4.5 Completion Certificate

Practitioners are often faced with the problem of obtaining acceptance of the works at the scheduled date. "Substantial completion" has unfortunately a variable definition following that interpretation is made by the client or by the contractor. Past experience proves that the exact definition of the words, substantial or non-substantial is never envisaged at a very early stage of the project. Which functions and tests for example are a prerequisit for the obtention of a certificate of substantial completion. Is the client allowed to maintain that the acceptance tests may only be carried out at the prescribed dates or may the contractor insist that a completion certificate be established before the contract period has elapsed. Would a premature completion imply that the client has to provide his contractual contribution in advance of the scheduled provisions. If the scheduled provisions may not be provided prematurely then the benefit anticipated by the contractor through accelerating his works in order to obtain early completion will not be secured. It is submitted that difficulties with and eventual refusals of the completion certificate fall within the scope of a contractor's risk.

2.4.6 Maintenance Certificate

The FIDIC Conditions of Contract provide that the construction contract is concluded only when a maintenance certificate is delivered. In Germany and other European countries the provisions are different in the sense that the period of guarantee during which the remedial work is required to be carried out is separated from the actual construction contract period. In other words the period of guarantee is subsequent to the construction contract.

2.5 Financial Results

A contractor, it is submitted, undertakes construction works in the hopes of obtaining a profit. For the purpose of securing this profit a number of methods are available to him. Therefore the contractor must be judicious in his choice of the appropriate and adequate method required in each particular case.

2.5.1 Tender Estimate

A tender estimate may be established following different methods. These methods consist principally in either a simple estimation of prices, or an extrapolation of previous results, or by a detailed study of the project under consideration. If the proposed tender includes for an itemized bill of quantities then the estimate will in general be built up following the items provided in the B.O.Q. It is underlined that the total costs of the contractor must be covered or included within these items. The laws of probability indicate that numerous bids have to be made before a contract is awarded. Therefore the amount of time that one may afford to this matter must be parsimoniously employed notwithstanding the required exactness of a tender estimate. Various systems are available however which allow processing estimates by the means of electronic appliances. The utilization of a computer has the advantage of allowing performance values to be stored and thereby readily available for future reference.

2.5.2 Work Estimate

Upon a contract being awarded a fully detailed work estimate should be produced to enable the contractor to ascertain the extent of his commitments and to afford him a valid basis for the purpose of planning and executing the project. This requirement is not always fully appreciated by contractors. The modifications to the original estimate due to negotiations prior to the award also have to be introduced into the work estimate. The work estimate should also contain the necessary details to permit all preparatory works and site installations to be set up within planned parameters. Budgets may also be established for various sections or units of the works thus forming independant cost plus profit islands. In certain instances an internal separate bill of quantities may be established based on the requirements of the contractor's network planning and cost control requirements rather than on the itemization of the performances as per the contract.

2.5.3 Quantity Survey

In the event of a unit price contract, the actual work executed is calculated by way of measurement of work executed, either physically on site or from drawings, based on the items contained in the B.O.Q. This method is adopted both for the preparation of monthly progress payments together with the appraisal of the final certificate. Certain construction contracts provide for this activity to be entrusted to an independant Quantity Surveyor. In other instances the contractor remains responsible for the fulfillment of this requirement. The Institute of Quantity Surveyors whose members are specifically qualified for the purpse of carrying out the aforementioned activities has rarely penetrated the continental European construction market.

2.5.4 Cost Control

Cost control, it is submitted, is required to be initiated right from the offset of the construction process. The system should be such that a regular course of procedure is achieved thus allowing the results obtained to serve as a reference for future estimates as well as providing the necessary information for the project under execution. For this purpose various computer aided systms are available. This particular aspect might be found to be an interesting subject for the 12th IABSE Congress in Vancouver.

2.5.5 Monthly Progress Payments

Where construction contracts provide for monthly progress payments the normal procedure requires these payments to be reconciled with the engineer and the employer. Quite often opinions differ as to the degree of exactness required for these invoices. From a legal point of view they are merely invoices for partial payment. Particular attention should be given by all the parties concerned in minimizing as fas as possible the period of time which elapses between establishing the monthly account and the ultimate receipt of the funds in the contractor's account. Prolongation of this period of time always results in the contractor incurring a financial loss which in some form or other is borne by the national economy and therefore also by the client. It is submitted that clients should avoid providing interim financing via delayed monthly progress payments.

2.5.6 Continuous Cost Control

A continuous and systematic cost control is to be implemented during the complete construction period. This continuous cost control consists of comparing the scheduled and actual amount of work executed in a given time together with evaluating the anticipated final monitary result. Various systems for the purpose of achieving this aim are available. In one particular system, performances and/or costs are strictly limited to each target date, thereby avoiding that advance performances do not falsify the result. In other systems the works yet to be executed are pre-estimated and extrapolation is made on the basis of data deriving from accountancy records. This allows elimination of all problems regarding the delimitation of costs and performances. Attention however is drawn to the fact that a source of error is possible when a subsequent activity has been newly estimated because the anticipated values might be erroneous.

2.5.7 Final Account

In theory, and in a general manner in practice, the acceptance of the final account brings to an end the construction contract. After acceptance of the final account no other payments for any contractual performance may be entertained. The form and presentation of the final account is to be agreed upon in due time with particular thought being given to the measurement sheets and subsequent calculations.

2.5.8 Final Balance Sheet

In instances whereby the final account brings the construction contract to an end, as far as its external relationship in concerned (excepting outstanding claims), the final balance sheet marks the end of the contract with regard to its internal relationship with the construction company. The final balance sheet defines to what degree the contractor's anticipated profit has been secured. For major construction sites it may appear on paper that a profit has been achieved. This profit however might be smaller than the residual value of the equipment that has not been depreciated. In this particular case only the demobilization of the site and the ensuing sales returns gained from selling equipment, camps, spare parts etc., will decide if the profit margin as shown on the balance sheet is factual or not.

3. INFORMATION SYSTEMS

Notwithstanding the presentation of Figure 2 it is underlined that the 5 main chains and their subsystems are not independant of each other. To the contrary there is a marked interdependence between the various chains. It is to be understood that this interdependence is not pictorially displayed in Figure 2 to avoid confusing the reader. It would be interesting to learn from practical experience which integrated information systems are available to illustrate this horizontal flow-chart simply but adequately. A suitable computer coding system could perhaps be helpful in this direction. It is emphasized that various theoretical models pertaining to available information systems are too complicated to allow their application within normal site conditions.

4. RESEARCH FOR SOURCES OF LOSS

In the comprehensive method of construction management of which it is question in this paper it is implied that all essential production and controlling activities are "anticipated" following a plan and that these activities proceed according to these plans. In the event that an anticipated result fails to be achieved corrections are implemented during the subsequent navigation. A further procedure which allows the improvement of results and which offers assistance in counteracting disturbances is known as the "control circuit scheme". This procedure however is not for ascertaining if the scheduled target has been attained but is for measuring any eventual loss of productivity. It is perhaps regrettable that this procedure has not been given appropriate consideration within the construction practice. It would be of great interest to obtain information of practical experiences within this field and to have the opportunity of debating same.

Figure 3 hereafter displays the aforementioned control circuit scheme.

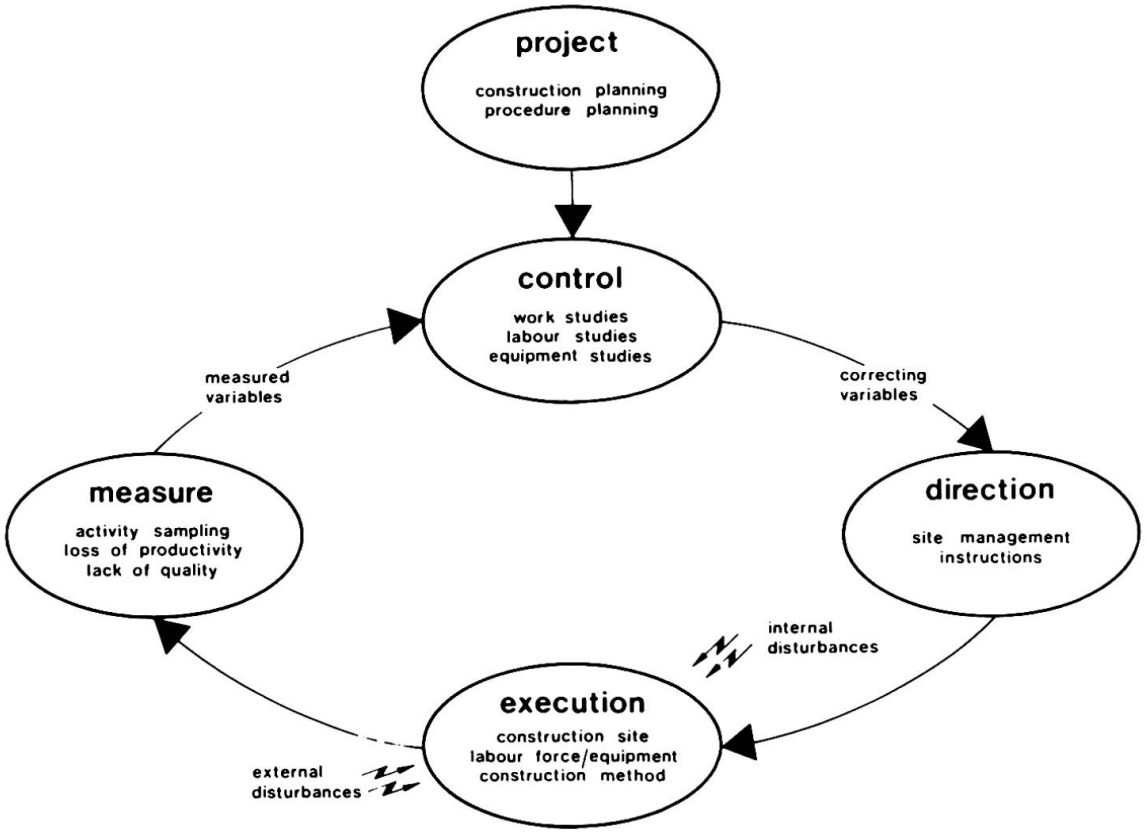

Fig. 3 Control Circuit Scheme

By means of methodical and systematic "activity sampling", observation of the current production activity of the labour force and equipment may be accomplished and statistically evaluated. [2] The "idle time" as measured is allocated to either internal or external causes of disturbance.
After affording the necessary corrections and adjustments to the workstudy the rectified information is recycled via the "control circuit" to those participating in the project. It would be of major interest to learn of experiences gained in working with such a "control circuit scheme" in actual practice and to have the possibility to debate its merits.

5. RISK MANAGEMENT

A systematic analysis of possible risk conditions is imperative in modern business. Risk has to be assumed otherwise no progress is possible. Risk may be defined as an exposure to mischance, the acuteness of which may be evaluated according to the probability of its occurrence and to the ensuing severeness of its consequences. It is submitted therefore that any risk inherent to a planned construction activity requires to be systematically ascertained. Risks require to be fully identified and evaluated in terms which will allow the contractor to accept or to refuse to cover the risk. [3] In the event that a particular risk is found to be unacceptable various alternative solutions are possible. Either the order or award is rejected, or the risk is eliminated or diminished by means of special measures of organization or by the selection of a more adequate construction procedure. Further possible alternatives are to transfer the risk to the client or to the subcontractors or to cover the risk, providing this is possible, by means of an appropriate insurance.

6. CONCLUSION

Experienced practitioners of Construction Management are invited to relate their particular experiences gained in the construction practice. A brief description of the project is required to illustrate the background of the subject matter under consideration. The members of the audience hopefully will be able to gather information and encouragement which will offer them help with their own particular projects and which also will allow them to draw their own conclusions. This Introductory Report is intended to be utilized by those participating in the Congress as an intermedium allowing relevant information and experience in the field of Construction Management to be either passed on, received or exchanged.

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