Design of Temporary Works

Projet d'installations provisoires

Der Entwurf von Bauprovisorien

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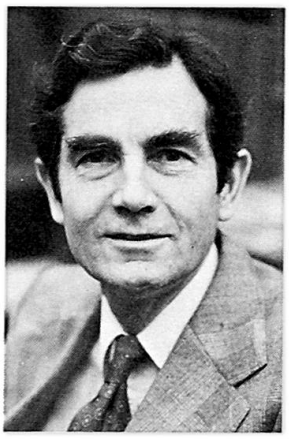

Born: 1926. BSc (Hons. Eng. London), FICE, FIStructE. Extensive design and construction experience on major works. Led team developing nuclear power station building and civil works. Joined Tarmac in 1967 to be responsible for technical performance, services and development. Involved in national research and development organisations.

SUMMARY

Temporary works provide access to and about the construction site, support the sides of excavations, provide working platforms and enable handling and shaping of elements under various environmental conditions. The particulars of the design, the construction and the use of temporary work is not always properly appreciated. The experienced temporary works designer will offer his views on the basis of the Contractor's and the Engineer's requirements. Inspection of used materials and components is necessary.

RÉSUMÉ

Les installations provisoires permettent l'accès au chantier, renforcent les parois de fouilles, établissent des plates-formes de travail et facilitent la manutention et le transport d'éléments, dans les conditions les plus variées. Les particularités du projet, de l'exécution et de l'utilisation des installations provisoires ne sont pas toujours considérées avec soin. L'ingénieur expérimenté dans les installations provisoires sait tenir compte des désirs de l'entrepreneur et du projeteur. Un contrôle des matériaux et éléments utilisés est indispensable.

ZUSAMMENFASSUNG

Bauprovisorien ermöglichen den Zugang zu Baustellen, das Erstellen stabiler Baugruben, das Arbeiten auf Arbeitsbühnen und Transporte unter unterschiedlichsten Umweltbedingungen. Die Besonderheiten des Entwurfs, der Ausführung und Benützung von Bauprovisorien werden nicht immer genügend beachtet. Der erfahrene Ingenieur wird bei seinen Entwurfsvarianten die Wünsche des Unternehmers und des projektierenden Ingenieurs berücksichtigen. Die gebrauchten Materialien und Komponenten sind zu prüfen.

Temporary works are designed and used in the construction of the permanent works and are removed when those works become self-supporting or are completed. Temporary works provide access to and about the construction site, support the sides of excavations, provide working platforms on which to cast or assemble the permanent works, enable construction in the sea or other waters, and enable handling and shaping of elements of the permanent works. Such temporary works usually take the form of sheet piling, trench sheeting, panel bridges, trestling, formwork, falsework, scaffolding, and lifting and launching equipments. Their design function is definable for a short working period under the specific loading conditions. The materials and components commonly used in temporary works should have the potential for re-use, be robust, easily connected to other similar members, be modular in concept, in pieces which can be readily handled during assembly or dismantling, and easily maintained between uses.

The Codes of Practice and Standards applying to construction work are generally intended to define acceptable qualities of materials and workmanship for the requirements of permanent construction. It is not usual for Codes of Practice to differentiate between the needs of temporary and permanent constructions which commonly employ the same qualities of steel, concrete, timber, soils and other structural materials.

The difference in approach to the design, construction and use of temporary works from those applied to permanent works is not always properly appreciated. Increasing refinements in the design of permanent structures, particularly the use of longer and lighter structures, have made greater demands on the contractor and his construction methods. The designs of the temporary works, which the construction methods require, have become increasingly critical to the success of the overall project and its safe construction. There is often interaction between the temporary and permanent work until the latter becomes self-supporting. Any recommendations of good practice for temporary structures must take account of the working conditions affecting the materials used and their safe working characteristics, the loading conditions and methods of design, and relate these to acceptable standards of workmanship. The maximum tolerable deviations during erection must be taken into account in the design, and should be compatible with the connections between members to avoid local overstressing. Bracing, lacing and web stiffening should be provided within the basic concepts of maximum re-use for the materials and components. Most failures in temporary works are started by the failure of a connection or a detail rather than the collapse of a main member.

Materials and Components

The materials used should comply with suitable existing national standards, and should be readily identifiable. When these materials are in the form of structural steel sections they should conform to

the acceptable dimensions defined for new materials so that the usual safe working stresses and section moduli may be used. Materials which do not comply due to the extent of surface deterioration should not be used unless exceptionally controlled by the use of lower assessed section properties or working stresses. Thus the continued re-use of materials is acceptable provided they can be assessed against recognised standards. In the case of timber the situation is not so straight-forward. The initial stress grading of timber is changing from visual to machine grading methods. As a result, the mechanical properties of different grades and species of fresh timber may be determined without human judgement. Timber is, however, a variable material and judgement is still needed regarding the acceptable incidence of knots, shakes, and other features. The conditions of the surfaces of re-used timber should be examined to detect any damage or deterioration. Most structural timber used in permanent works is confined to a dry environment within a building whereas temporary works conditions are usually in the open with the timber subject to atmospheric conditions. Thus, with the exception of arid climates, different stress values may be appropriate for temporary works. Since temporary works usually involve maximum design loading for only short periods of time it is often possible to accept higher working stresses than would be advisable in permanent works.

Fabricated components should be used in the manners intended by their designers. The component designer should have demonstrated by a suitable test programme the basis for the recommendations for safe working loads and limiting deflections for the intended uses. In particular, the component designer should indicate the nature of regular inspections between uses to ensure that the components are always fit for use. Where doubt might arise as to the stress grade of the material or other properties of a component, then that component should be marked to enable ready identification.

The exposure of temporary works materials and components to construction operations, and the successive erection, dismantling and transport between uses, requires suitable methods of protective treatment and adequate section thicknesses with due regard to the economics of the total cost of purchase, use and maintenance during their useful life.

Loading conditions and method of design

A permanent structure is designed for a life of several decades and the specified loading conditions are the prediction of the most severe conditions to which the structure may be subjected during that period. This may possibly occur at a time when some deterioration has developed, other than that which regular maintenance is intended to prevent.

In contrast, a temporary structure is designed to meet a short term need for usually a period of weeks rather than months or years. The condition of the structure will be readily inspected prior to loading, and the applied loads, other than environmental ones, can be controlled. Extreme design conditions, such as the combination of high winds at the time of placing concrete, can be precluded by prohibiting crane operations when the wind speed exceeds 18 m/sec when it would be difficult to operate jibs and booms on exposed sites in any case.

Wind loading is an interesting case due to the limited research which has been directed at temporary works structures, particularly of the multiple tube variety, and the necessarily statistical approach to wind speed probabilities for such short periods as one to six months.

Recent investigations show that the wind loads applied to multiple layers of tubular or truss structures have maximum values for given wind speeds irrespective of the number of layers, providing the wind is constrained to pass through the structure and not escape laterally.

Computer programmes for the calculation of lateral loads on earth and water retaining structures give engineers the ability to assess the effects of varying ground conditions on permanent and temporary structures. This is particularly valuable to the temporary works designer to achieve an economic design and assess different limiting conditions and the probability of their occurrence. Operational research techniques are used to determine the flood risks associated with different cofferdam heights from studies of river level records.

The measurement of loads in falsework structures is expensive and the limited data obtained has shown the complexity of distribution of load among the members. The imposed loads on temporary structures resulting from the items and operations they support are readily quantifiable but the environmental or soil loadings are less so. The tolerable deviations allowed for erection often give rise to eccentric forces, which need horizontal restraint, and the development of preferential load paths before all the members receive their predicted shares of the loading. In tall falsework structures the most severe load conditions may sometimes arise during erection due to overturning wind forces, prior to the imposed vertical loading being applied.

A systematic approach is needed for the design of temporary works and all the interested parties should subscribe to the design brief. The Contractor will indicate how and when he intends to carry out the work and the resources made available. The Engineer for the permanent works will specify his requirements and any limitations which the design of those works impose on the method of construction. He will provide information regarding already-constructed sections of the permanent works which may be used to support temporary works or concerning subsequent operations such as post-tensioning which may induce additional or varied loads into the temporary works. The experienced temporary works designer will offer his views on the options available in the light of these requirements and, following agreement of the design brief, will produce the necessary calculations and drawings. It is important that these proposals are checked using appropriate Codes or other documents describing acceptable standards and principles.

Site Workmanship

The definition of tolerable deviations from the theoretical positions on drawings is clearly important. Guidance should be given as to the critical aspects of work on site and how and when these should be assessed. Exposed formations and sides of excavations should be inspected to see whether the soil conditions are as expected and the

designer's specified requirements therefore still suitable. The materials and components used should be inspected before and after use. There should be a control procedure so that the temporary works are not loaded until they have been checked as ready, and then only in the manner described in the design brief. The temporary works should be protected against deterioration from scour, weakening of formations, and uncontrolled lateral loads or impacts.

The determining requirement dictating how and when the temporary works can be removed should be clearly specified. These works should be removed with care and safety to avoid unnecessary local stressing of the permanent works or the temporary works. Even structures able to be self-supporting may deflect as the temporary works are removed. Substantial increases in load can occur in the remaining temporary supporting members when some are removed if they have not all been progressively relieved of load.

Conclusion

Little authoritative guidance appears to be available which is particularly relevant to the design and execution of temporary works. The differences in philosophy which temporary works designers apply compared to those used for the designs of permanent works need to be defined so that standards of performance may be uniformly good and safe. Such definitions will allow ready agreement to be reached between those who undertake design or site responsibilities and those who have to check them. Considerable progress is being made in Britain and probably elsewhere. It seems desirable to have an international exchange of views and information so that progressive improvements in all countries make the best use of the applied resources to achieve better structural results with safety and economy.

References:

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