Building under extreme enviromental und infrastructural restrictions

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Objekttyp: **Article**

Zeitschrift: **IABSE congress report = Rapport du congrès AIPC = IVBH Kongressbericht**

Band (Jahr): **11 (1980)**

PDF erstellt am: **21.09.2024**

Persistenter Link: https://doi.org/10.5169/seals-11199

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Building under Extreme Environmental and Infrastructural Restrictions

Construire dans des conditions extrêmes d'environnement et d'infrastructure

Bauen unter extremen Infrastruktur- und Umweltbedingungen

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SUMMARY

This report outlines the extreme environmental and infrastructural restrictions and discusses their influence on building design and construction. The restrictions may include shortage of materials, limited equipment and transport facilities, limited availability of skilled personnel, socio-economic and time factors. Development of appropriate construction technologies depends on adequately identifying these restrictions and taking them into account at all stages of a building project.

RESUME

Ce rapport esquisse les restrictions extrêmes d'environnement et d'infrastructure et présente leur influence sur le projet et l'exécution de constructions. Les restrictions peuvent avoir trait à un manque de matériaux, à un équipement et une infrastructure de transport de faible qualité, à une offre limitée de personnel qualifié, ainsi qu'à des facteurs socio-économiques et de temps. Le développement d'une technologie de construction appropriée dépend de la connaissance et de l'appréciation de ces restrictions ainsi que de leur prise en considération à chaque étape du projet.

ZUSAMMENFASSUNG

Dieser Bericht zeigt diejenigen Randbedingungen auf, die durch die Infrastruktur und extreme Umweltverhältnisse verursacht werden, und erörtert deren Einfluss auf den Entwurf und die Ausführung von Bauten. Unter Einschränkungen zählt man Mangel an Baumaterialien, Ausrüstungs- und Verkehrsanlagen, beschränkte Anzahl von Fachleuten und sozio-ökonomische sowie zeitliche Umstände. Die Entwicklung passender Bauverfahren hängt von einer genauen Kenntnis dieser Einschränkungen und deren Beachtung während aller Entwurfs- und Bauphasen ab.

1. INTRODUCTION

Building design and construction are influenced by a number of factors including local physical, environmental and infrastructural conditions. The success of a building project, therefore, depends on understanding these conditions and adopting suitable methods of design and construction. This is particularly important for building activity in a developing region where environmental and infrastructural restrictions may not allow the use of conventional methods of construction.

The environmental and infrastructural restrictions may include shortage of materials, limited equipment, limited availability of skilled personnel, transportation and communication problems, socio-economic and time factors. Overestimation of resources and facilities or underestimation of difficulties in the design of a building project may lead to lengthy delays during construction, overrun costs, legal complications, substrandard end product or even structural collapse. It becomes, therefore, imperative to develop suitable designs and advance appropriate construction technologies in keeping with the extreme local conditions and restrictions. The specifications for works should also be consistant with local conditions, materials and equipment.

The paper describes the extreme environmental and infrastructural restrictions and discusses their influence on building design and construction. Several innovations in the fields of design and construction have recently been made for the speedy development of various regions of the world. It is not possible to present all such innovations and detailed case histories in one paper. The scope of the present paper is therefore limited to the discussion of main aspects of environmental and infrastructural restrictions and development of appropriate construction techniques.

2. BUILDING MATERIALS

Availability of materials plays a major role in the successful completion of a building project. At present, concrete and steel are the two main materials of construction. Steel is not locally produced in many countries and therefore it may not be feasible to construct a large number of steel structures in these countries.

Production of concrete also depends on the availability of constituent materials, e.g., cement and aggregates. It is usually most economic to use locally available aggregates to avoid increase in transportation cost and large storage at construction site. Depending on geographical location and source, some aggregates may not conform to relevant specifications. These aggregates should not be rejected solely on their physical properties, but should be tested in trial mixes to assess their suitability in terms of strength and durability of the concrete produced.

Due to tremendous increase in construction activity, there is a shortage of cement in many countries. The shortage can be overcome by setting up more cement plants or by importing cement from other countries. However, setting up of a new plant cannot be regarded within the purview of a building project and may have to be decided on a national level depending on the total demand of cement in the region. Import of cement may not be an economic proposition except for construction work in

border and coastal areas. Inland transportation of the imported cement may raise its delivered price substantially, thus affecting overall cost of the construction work.

Economy in the use of cement can be obtained by adopting proper methods of mixing and placing concrete and also by using good formwork to get smooth concrete surfaces which do not need plastering.

Special types of reinforcing steels and bar sizes above 1 in.(25 mm) diameter may not be readily available in certain areas. Some countries have recently changed to SI units of measurements but have not yet redesignated and produced metric reinforcing bars. Therefore, to avoid delays and gross mistakes at the site, working drawings should be prepared keeping in view the available materials and sizes.

In some regions it may be more economical to use brick or stone masonry than concrete construction for buildings up to 4 storeys. In the case of limited availability of portland cement, other cementing materials can be used for making mortars for brickwork and stonework. Gypsum, lime and pozzolanas have been used in various parts of the world for making mortars. In Pakistan, India and Egypt powdered broken tiles and pottery are also used for making mortar in minor masonry works.

Soil-cement blocks were introduced in many countries some time ago for low cost construction to replace the traditional mud or adobe dwellings. Recent studies indicate that due to increase in the price of cement, soil-cement block construction cannot be regarded 'low cost'. Therefore, in order to maintain the usefulness of this appropriate construction technology of machine made adobe blocks, it is essential to find out alternate cheap stabilizing materials. Lime may be used as a stabilizing material and studies are in progress to determine the optimum values of lime and water for making lime stabilized blocks.

To overcome the shortage of building materials research is also in progress on other locally available materials, including agricultural and industrial wastes, which may prove useful for constructing various types of structures.

3. CONSTRUCTION EQUIPMENT

In order to obtain certain standards it becomes imperative to use some mechanized operations in building construction. For example, large quantities of concrete cannot be produced without a concrete mixer. Development of an appropriate construction technology may, therefore, necessitate the introduction of simple and readily available equipment for achieving the desired standards. Cinvaram, the hand operated block making machine, can be an example of this type of equipment. Cinvaram is now locally manufactured in many countries. Two skilled labourers can use one Cinvaram for making about 300 blocks of stabilized soil in one day.

Most of the heavy construction equipment is not locally manufactured in developing countries, and therefore, limited equipment and machinery may be available at a building project. Efficient use of the available equipment can be made by analysing the operation of each machine and carefully planning the construction work. For example, at most construction sites a crane (mobile or tower) may be the only equipment available for handling formwork and steel reinforcement and also for placing

concrete above ground level. Building work can be successfully accomplished with the crane if all the operations are preplanned and a balanced cycle between different operations is maintained.

In some countries the energy crisis may also limit the use of mechanized means of construction. Maximum use of the available labour should be made in such cases. For example, unskilled labour can be used for excavation of building foundations and earthwork in road construction. However, it will be mandatory to employ compaction equipment for getting desired results.

Proper sequence in construction work can also be helpful in overcoming equipment shortage. In low-rise buildings if staircases are completed simultaneously with other construction, the stairs can be used for transporting materials and tools to work points above ground level. Concrete and bricks can be head carried in metallic baskets to the underconstruction level by labourers.

The design of precast concrete members and steel structure components and arrangement of shop and field connections should be carried out keeping in mind the available erection and transportation methods. Capacity of handling, erection and transporting facilities will control the weight and lengths of various members.

With limited equipment at a construction site, the need for its repairs and maintenance becomes very important, because breakdown of some machinery may mean stoppage of construction work. Therefore proper facilities for regular inspection, lubrication and maintenance work should be provided to keep the available stock in a running condition.

Materials testing equipment forms an essential part of modern building industry for maintaining quality and developing new materials of construction. Quite often adequate testing facilities are not available near the construction site and it becomes difficult to employ worthwhile quality control measures. Experience has shown that in such cases non-destructive methods of testing can be effectively used for checking quality and detecting defects during construction. Inexpensive and portable equipment is now available for conducting non-destructive tests. However, limitations of non-destructive methods must be kept in mind while interpreting the test data.

4. TRANSPORTATION AND COMMUNICATION

Lack of communication and transportation facilities may hamper speedy procurement of building materials and equipment and cause delays in the completion of a project. Construction techniques should, therefore, be developed keeping in view the limited transportation and communication facilities available in a region.

Besides irregular supplies of building materials, narrow and substandard roads may affect the working of ready mixed concrete industry in a developing region. The situation may be further aggravated due to non-existance of a communication system, say, a two-way radio, as most developing countries do not allow private use of a radio or wireless set. In such cases, it may be more appropriate to install small or medium sized ready mixed concrete plants in various parts of a city than a big plant. Telephone connections at the plant and the construction site may provide the necessary communication link.

The selection of a definite method of industrialized construction also depends, to a great extent, on the transportation system. For example, the use of heavy panels and box modules may not be feasible at present due to nonavailability of special trailers and good roads (1). However, precast beams of usual spans and slab units have been transported by medium sized trucks, even over long distances, for the construction of houses, schools and hospitals in many developing countries. In the absence of proper roads and trucks, horse and ox drawn carts have also been used to transport simple precast elements in remote areas without appreciable breakage.

Precasting and prestressing at site can be used to overcome shortage of transportation facilities. This method has been successfully used for the corstruction of major highway bridges in many developing countries. Precasting at site can also be used for large building projects. This method of construction will be particularly useful when sufficient space is available near the site to set up precasting plants.

Besides roads and railways the use of other types of transportation system should also be explored. In some cases waterways can provide excellent means of transporting materials and equipment.

5. SKILLED MANPOWER

Architects, engineers, managers, technicians and labourers form a part of the manpower needed for designing and executing building programmes. In many countries labour is available but engineers and other qualified supervisory personnel are not available. In some other countries there is a shortage of expertise and skilled labour. An analysis of the failures of four bridges in Bangladesh (2) indicates that the lack of supervision during construction due to the shortage of experienced engineers was the main cause of the bridge failures. In most cases the reinforcement had not been placed according to the detailed drawings of various bridges.

The oil-rich developing states which are deficient in construction materials, equipment and labour imported almost every thing from other countries for their building projects. In such cases the approach is to develop structural systems and construction technologies which require a minimum of manpower and a short construction period. This objective is achieved by using sophisticated materials and advanced construction equipment.

Export of labour to oil-rich developing countries has caused a shortage of skilled labour in other developing countries. Labour in these countries is now not cheap when considered in terms of skills and output.

The success of labour intensive methods of construction also depends on the effective control over the labourers by experienced supervisory staff. Therefore, there is a need to develop improved construction management techniques taking in to account the local socio-economic and political conditions.

The shortage of skilled personnel cannot be solved in an overnight. Appropriate steps should be taken to establish technical institutions and training centres for producing qualified engineers, managers and other skilled personnel. The objectives of these institutions should be

to teach the modern know-how of building design and construction and practical ways of adapting this know-how to suit local materials, tools and methods. Opportunities of continuing education should also be provided to the technical personnel working in developing countries to improve their knowledge.

6. SOCIO-ECONOMIC CONSTRAINTS

Building projects should be constructed at a cost society can afford. It may not be within the constraints of available resources to implement very spectacular, luxurious and expensive plans. The designs should, therefore, be simple and functional. Specifications and quality of workmanship should also be in keeping with the ultimate use of the projects.

Socio-economic constraints may include settlement patterns, family size and organization, educational levels, employment, distribution of wealth, cultural and religious practices. These constraints will influence planning and design of projects as well as methods of construction. For example, it may be considered appropriate to adopt labour intensive building techniques for a large project as such techniques will also provide a means of unemployment relief for the region. In rural areas it may be possible to develop appropriate construction techniques for dwellings and farm houses on a self-help basis. In these methods rural families construct their houses on a self-help or mutual aid basis with or without technical and financial support from government. Such schemes of rural development are already in operation in many countries.

Design of houses, schools and work spaces should take into consideration the local climatic conditions and sociological needs as most people cannot afford artificial heating/cooling arrangements and other services. Inadequate identification of these needs may lead to partial or total rejection of the constructed facility by the intended occupants. Most of the low cost housing techniques developed during the years do not provide adequate thermal comforts. The saving in cost has been permitted by reducing ceiling height and thickness of walls without paying much attention to the climatic conditions. In some new type of houses constructed in rural areas of Turkey (3) the bathroom and kitchen became useless as no running water was available. These services were ultimately converted into stores for crops because no provision existed in those dwellings for storing agricultural produce.

Maintenance also forms an important part of building construction. Only such structures, finishes, paints and fittings should be used which are in complete harmony with the social and economic characteristics and require a minimum maintenance. It has been observed that some times consultants specify expensive materials and fittings which are not locally available and replacements are difficult to obtain. The building therefore presents an ugly appearance due to broken fittings and worn out paints and finishes.

7. TIME RESTRICATIONS

Time factor assumes a great importance in modern construction industry. Worldwide inflation, increase in construction volume and energy crisis are some of the factors which impose time restrictions on building projects.

Lengthy delays in the completion of a project may affect its overall cost. These delays can be avoided if causes of difficulties are adequately identified and considered in design and construction. Each operation of design and construction should be carefully analysed and scheduled. Alternate solutions should be considered to determine the most efficient, economical and time saving procedures. Material and equipment delays should be avoided by advance procurements and expediting deliveries. These steps certainly call for a team work by the planner, architect, engineer and contractor.

Considerable savings in time can be obtained if drawings are available at the start of the project. Excavations can start even before the completion of drawings, provided the general layout and certain structural dimensions are known.

As mentioned earlier, alternate materials and methods can be used to reduce construction time. For example, in precast concrete construction the duration of production cycle can be reduced (and thus output increased) by using high alumina cement in place of portland cement or by using steam curing procedures for portland cement concrete.

Construction management techniques should be applied to minimize the risk of not completing a project within estimated cost and time. The critical path method may be used to plan, analyse and control a building project. Abnormal time limitations may require a project to be completed under a crash programme of construction (4). Crash programme may be implemented by increasing the rates of providing materials, increasing the labour force and/or increasing the construction equipment. This programme may also require the available labour to work overtime at premium wage rates. Therefore, crash programme may result in an increase in the overall cost of construction. An analysis by the critical path method can be carried out, using possible alternatives, to select the schedule which requires a minimum increase in the cost.

8. CONCLUSIONS

There are a number of environmental and infrastructural constraints which influence building design and construction in a developing region. These constraints may include availability of materials, equipment, transport and manpower, energy supplies, cultural and religious practices and time limitations.

Appropriate methods of design and construction should be developed in keeping with these constraints. Building projects must be correct in concept right from the feasibility studies to the ultimate use of the constructed facilities. These facilities must be socially and economically justified.

Due to the rapidly increasing oil prices, energy consumption in building construction has assumed a great importance in recent years. Studies in developed countries (5) indicate that structures in concrete consume the lowest energy when compared with similar structures in steel or brick. Such studies should also be carried out in developing regions on locally available materials and methods to find out appropriate construction technologies which require a minimum consumption of energy.

In the development of appropriate construction technologies success can be achieved if the environmental and infrastructural constraints are

properly identified and the planners, architects, engineers, contractors and other technical personnel work as a team.

Management techniques must be applied for the proper planning of construction works in developing countries in order to obtain savings in cost and time.

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