
AC 2011-695: CONSTRUCTION WORK WITH EQUIPMENT: INDIA

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CONSTRUCTION WORK WITH EQUIPMENT: INDIA

In India, the majority of the residential buildings are constructed on a contract basis. Here, an owner who wishes to build signs an agreement with a contractor, taking specific requirements under consideration. Generally, a permit, house plan, structural design and a contractor are required for construction. Here, the work is usually labor intensive and a great number of workers are utilized on the site. Nevertheless, industrial and other large projects tend to use modern construction techniques with the application of large equipment^{19, 20}. This approach is discussed in the paper.

Construction is continuously facing new demands and pressures. The impact of globalization, the advance of technology, and cultural changes are just a few of the issues that are affecting the industry. Hence, construction around the world, both in developed and developing countries, is facing challenges created by these and numerous other issues. The identification of these issues is more critical for developing countries as it would assist in defining research and development efforts to address them more effectively¹⁰.

In order to introduce the concept of global construction to university students a seminar was developed to investigate the subject as well as that of green and sustainable construction. Numerous papers were written and presented at meetings of organizations such as The Texas Section of ASCE and the Gulf-Southwest Section of ASEE. Students were also requested, at times, to present their finding in the building construction course. This has been found to be a good method to increase, in students, the level of knowledge associated with the global aspects of construction and civil engineering⁹. For example, this paper presents photographs of mechanized construction equipment which may be utilized in India and around the world. Comparison can be made with studies of labor intensive operations at numerous construction sites in India^{9, 13}.

Introduction

The evolution of Indian Construction Industry is almost similar to that in other countries founded by the Government and slowly taken over by private enterprises. After independence, the need for industrial and infrastructural developments in India laid the foundation stone for construction.

In the late 1960s the government started encouraging foreign collaboration in construction. The Guidelines for Foreign Collaboration, first issued in 1968, stated that local consultants would be the prime contractor in such collaboration.

The objective of this imposition was to develop local design capabilities parallel with the inflow of imported technology and skills. This measure encouraged international construction and consultancy organizations to set up joint ventures and register their presence in India.

In India, construction has accounted for around 40 percent of the development investment during the past 50 years. Around 16 percent of the nation's working population depends on

construction for its livelihood. The Indian construction industry employs over 30 million people and creates assets worth over 200 million rupees. It contributes more than 5 percent to the nation's GDP and 78 percent to the gross capital formation^{19, 20, 21}. Total capital expenditure of state and the central government will be approaching 80 million rupees in 2011-12 from 10 million rupees in 1999-2000.

The Indian construction industry comprises 200 firms in the corporate sector. In addition to these firms, there are about 120,000 class A contractors registered with various government construction bodies. There are thousands of small contractors, which compete for small jobs or work as sub-contractors of prime or general contractors. Total volume of the construction industry reached 42,885 million in 2004-05 up from 21,451 million in 2000-01²¹.

The rapid increase of the urban population in developing countries such as India has forced the reevaluation of the importance of high-rise buildings as shown in Figure 1. In developing the various construction operations of multistory buildings and industrial facilities, timely completion and quality must be considered. The quality of construction is dependent, in part, upon the construction techniques adopted to erect the building.

In most developing countries such as India, the construction industry is highly dependent upon the labor force¹⁴. However, in metropolitan cities, where the population growth rate is high, the use of mechanical equipment as described in this paper may also play an important role in increasing construction productivity.

Heavy machinery is scarcely available to small contractors, but the CIDC (Construction Industry Development Council), an organization in operation since August 8, 1996, has attempted to overcome this problem by establishing the Construction Equipment Bank where modern equipment is available at reasonable rental prices²². Many private equipment rental agencies have also joined the effort to improve the availability of new highly efficient equipment.

This paper describes, in general, the reinforced concrete process since it appears to dominate construction in India. At this period of time the construction industry in India may be considered unique since it is transitioning from a very intensive process to one that operates in an environment using mechanized equipment. Figure 2 illustrates such an operation.

There are basically four different stages of construction whether equipment or labor intensive methods are utilized:

- Planning
- Design
- Estimation
- Construction

Planning

Key elements to be considered in planning are as follows¹⁶:

1. The plan of any facility which is to be designed by an architect should be according to the guidelines of the local municipal corporation¹⁴.

2. Estimation is made once the plan is approved by the local corporation.
3. A good contractor should be selected based on experience and work on the previous projects.
4. Contract agreements must include specifications of the materials to be used and their cost per unit area and the mode of payment¹⁶.

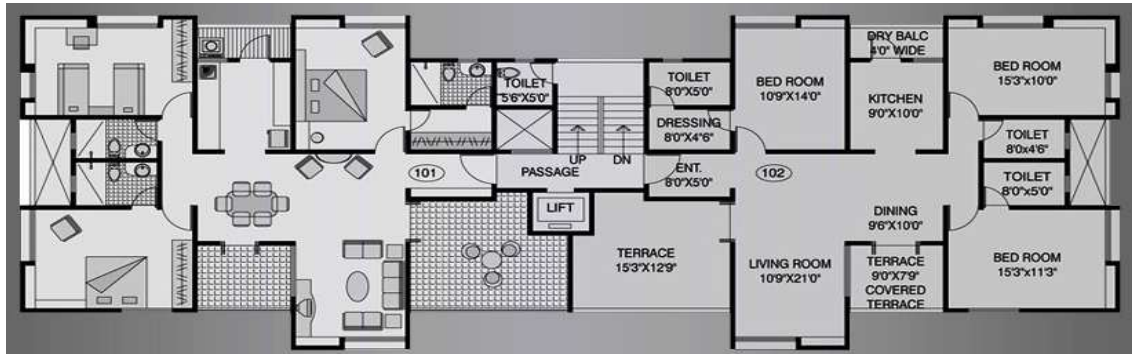


Figure 1 Floor Plan of a building

Design

Following the development of the plan of a building by an architect as illustrated in Figure 1, the structural design is accomplished by a structural engineer¹⁸.

Where cement concrete 1:2:4 is specified, it means 1 part of cement 2 parts of fine aggregate/coarse sand and 4 parts of coarse aggregate. This ratio of cement concrete gives high strength and is recommended for the following work^{15, 17}:

- General RCC work in buildings
- Bed plates
- Lintels
- RCC shelves
- Pavement etc.

Where cement concrete 1:1.5:3 is used; it means 1 part of cement 1.5 part of fine aggregate/coarse sand and 3 parts of coarse aggregate. This ratio of concrete also gives very high strength of cement concrete and is recommended for the following works^{15, 17}.

- Structures carrying heavy loads
- Important RCC structures such as columns, beams, supporting slabs, cantilevers, porches, and balconies, etc.
- Earth quake resistant facilities.

Estimation

With the help of a detail estimate the materials can be ordered according to the needs at a site. This will avoid unnecessary storage of materials, reduce the wastage of materials, and also save unnecessary carriage charges and time.

Other important items are as follows:

- Arranging all the materials according to need will help to increase productivity.
- Detail estimates also involve determining the specification of the material required for the construction which will help in checking of the quality of the materials at the site.
- If all the materials and labor are arranged according to need it will help for timely completion of construction work which will save the expenditure spent on storage, watchman etc.
- Timely completion means timely use of the facility. Large projects in India such as the Delhi Metro were completed on time because they used these estimation techniques to identify the exact quantity required at a specific time¹⁶.
- Computer software may be utilized in the estimation process.

Construction

This is the major stage of all the activities. For construction, the owner can hire a contractor who manages the skilled labors, masons, plumbers, electricians and painters etc., to get the work done in time^{13, 17}.



Figure 2 Boomplacer: Modern Equipment in India

The various Phases in Construction and procedures are as follows:

- Ground Improvement Techniques or Consolidation
- Laying of Plain Cement Concrete
- Laying of Foundations
- Columns Erection
- Soil filling
- Laying of Plinth beam
- Form work, slab form work (shuttering) and concreting of the slab.
- Brick work
- Doors, windows and the interior construction work.

Laying of Plain Cement Concrete (P.C.C):

- After checking the ground for the consistency, plain cement concrete layer of required thickness is laid in the excavated pits.
- The ratio of Plain Cement Concrete is maintained as 1:2:4.
- The plain cement concrete is cured with water for one day for required strength⁶.



Figure 3 Laying of P.C.C

Laying of Foundations:

- On the Plain Cement concrete, the centre of the footings are marked using total station or any other instrument as shown in Figure 3.
- Depending on the type of foundation, the footing steel is arranged and the steel mat is laid on the plain cement concrete as per the markings of the footing (Figure 4).
- The chair rods made of steel are used to support the top steel and the shuttering formwork is placed for the footing to be concreted¹⁵.
- Spacer blocks are used which are made of small concrete blocks in order to ensure that the mat steel bats are inside the footing.
- The shuttering (formwork) is placed for the footing and supports which can withstand the concrete without bulging when the concrete is poured into the footing.
- The concrete is poured into the footing using manual concreting or from a batch plant using a machine called boom placer as illustrated in Figure 2¹¹.
- A vibrator needle is used to ensure the concrete is well poured into the footing as well as for the compaction of the concrete.
- The next day, the footing is cured to obtain the required design strength.



Figure 4 Laying of Foundation

Column Erection:

- The column rods are bounded by the ties or rings depending on the shape of the column with enough spacing as per the design and illustrated in Figure 5.
- The bars are tied with enough spacing and the formwork (shuttering) is checked for the straightness using a plumb bob⁵.
- The shuttering (formwork) is covered with oil for easy removal after the column is concreted and checked for the strength and straightness before concreting.
- The column is concreted using boom placer as shown in Figure 2 or manually. On the top of the column a key joint may be provided for the next column.
- The concrete is well cured for 1 or 2 days to ensure it attains the required strength^{9, 17}.



Figure 5 Erection of Columns

Laying of Plinth Beam:

- The plinth beam illustrated in Figure 6 is reinforced with the steel from column to column.
- The concrete spacer blocks are used at the bottom to make sure that there is enough space between the bottom surface and the steel reinforcement.
- The concrete spacer bars and the steel spacer bars are also used between the plinth reinforcement and the shuttering (formwork).
- The concreting is done manually as shown in Figures 6 and 7 or using a boom placer with a concrete pump.
- A vibrator needle is used to make sure the concrete is well placed into the beam⁵.



Figure 6: Concreting of plinth beam



Figure 7: Plinth Beam overview

Formwork, slab shuttering and concreting of the slab:

- Steel or timber falsework members support the slab shuttering. The material used depends on the size of the project. For large projects and facilities steel is used. For the smaller projects like individual houses timber may be utilized.
- The slab shuttering (shown in Figures 8, 9, 10) is covered with the oil for ease of removal from the concrete.
- Proper cover is provided for the slab using the concrete cover blocks and the spacer bars.
- A concrete machine is mounted in place to transfer wet concrete to the required location. A boomplacer may also be utilized.
- The vibrator needle is used to ensure the concrete is well compacted after it is placed on the slab.

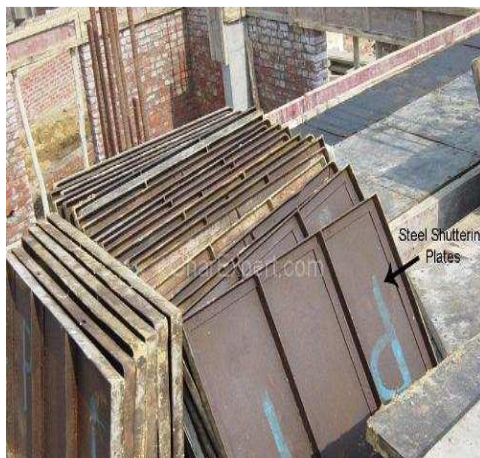


Figure 8: Shuttering Plate



Figure 9: Shuttering plates set for slab

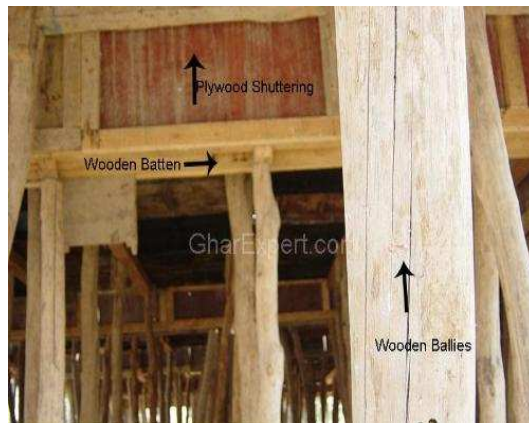


Figure 10 Bamboo used as falsework

CONSTRUCTION EQUIPMENT

India's Construction Equipment Industry – Highlights

- Volume – about US \$ 2.4 – 2.64 billion for the year 2007
- Spans a range of equipment for all construction/infrastructure needs
- Growth of over 30%
- Exports growing at 30%-expected to be US\$ 100-200 million by 2010
- Highly fragmented top 6 of about 200 domestic manufacturers contribute 60% of output³.

The Industry spans a range of products and services

- Products and spare parts constitute the bulk of the industry
- Services segment is still nascent and presents opportunities for growth
- The unorganized sector contributes about 15% by value though the majority of players are in this sector¹.

The key segments that constitute the Construction Equipment industry in India are manufactured, in part, in the country are listed below.

- Concrete equipment
- Earth moving equipment
- Material handling equipment
- Construction vehicles
- Material preparation
- Road construction equipment
- Tunneling & Drilling equipment

Concrete equipment:



Figure 11 Ready Mix Concrete Vehicle



Figure 12 In-situ concrete mixer

Earth moving equipment includes^{10, 12}:

- Backhoe Loaders (Figure 13)
- Excavators (Figure 14)
- Loaders (Figure 15)
- Bulldozers (Figure 16)
- Skid-Steer Loaders (Figure 17)
- Shovels (Figure 18)

- Wheel Loaders (Figure 19)
- Motor Graders (Figure 20)
- Motor Scrappers (Figure 21)
- Dump Trucks (Figure 22)
- Wheel Dozers (Figure 23)
- Draglines (Figure 24)



Figure 13 Backhoe Loader



Figure 14 Excavator



Figure 15 Loaders



Figure 16 Bulldozers



Figure 16 Skid Steer Loader



Figure 18 Shovel



Figure 19 Wheeled Loader



Figure 20 Motor Grader



Figure 21 Motor Scraper



Figure 22 Dump Truck



Figure 23 Wheel Dozer



Figure 24 Dragline

Material handling equipment includes^{3, 7, 8}:

- Telescopic Handlers (Figure 25)
- Crawler Cranes (Figure 26)
- Mobile Cranes (Figure 27)
- Truck Cranes (Figure 28)
- Forklifts (Figure 29)

- Pick & Carry Cranes (Figure 30)
- Slew Cranes (Figure 31)
- Tower Cranes (Figure 32)



Figure 25 Telescopic Handler



Figure 26 Crawler Cranes



Figure 27 Mobile Cranes



Figure 28 Truck Crane



Figure 29 Fork Lift



Figure 30 Pick & Carry Cranes



Figure 31 Slew Crane



Figure 32 Tower crane

Construction vehicles include⁹:

- Dumpers (Figure 33)
- Articulate Haulers (Figure 34)



Figure 33 Dumpers



Figure 34 Articulated Hauler

Growth

Growth in the industry is expected to be driven by the 3 key factors listed below:

- Infrastructure investments

1. Investments in roads, ports, power etc
2. Housing including high rise construction
- Industrial production/capacity expansion by manufacturers
 1. New Facilities
 2. Upgrading existing facilities-demand for material handling equipment
- Emerging growth areas
 1. Leasing/Rentals
 2. Exports
 3. Refurbishing used equipment
 4. Services

Future Challenges

The Indian economy has witnessed considerable progress in the past few decades. Most of the infrastructure development sectors have moved forward, but not to the level of increasing the growth rate up to 8 or 10 percent. The national Government has underlined the requirements of the construction industry.

With the present emphasis on creating physical infrastructure, massive investment is planned in this sector. The Planning Commission has estimated that the investment required in infrastructure should be roughly US \$320 billion during the next Five Year Plan period.

This is a requirement of an immense magnitude. Budgetary sources cannot raise these resources. The Public Private Partnerships (PPP) approach is best suited for finding the funding required. Better construction management is also needed for optimizing resources and maximizing productivity and efficiency²¹.

Summary and Conclusion:

- Recent statistics show the development of infrastructure and construction activities in India. This has provided substantial employment to a large number of people and increased the socio economic development of the country³.
- The various monumental structures constructed in India illustrate the effectiveness of the construction materials used in addition to possible safe work practices.
- Stage wise construction work and strategic plans regarding cost estimates make a clearer picture for budget allocations so that possible delays in construction can be minimized.
- The effective use of sophisticated machinery for construction practices in addition to maintaining the traditional labor work practices and skills helps the industry.
- The various materials used for construction in India illustrate the abundance and richness of Indian natural resources and their proper utilization in design²¹.

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