Challenges before Construction Industry in India

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Abstract

The construction industry is the second largest industry of the country after agriculture. It makes a significant contribution to the national economy and provides employment to large number of people. The use of various new technologies and deployment of project management strategies has made it possible to undertake projects of mega scale. In its path of advancement, the industry has to overcome a number of challenges. However, the industry is still faced with some major challenges, including housing, disaster resistant construction, water management and mass transportation. Recent experiences of several new mega-projects are clear indicators that the industry is poised for a bright future. It is the second homecoming of the civil engineering profession to the forefront amongst all professions in the country.

1. CONSTRUCTION INDUSTRY AND NATIONAL ECONOMY

Presently, the annual expenditure budget of India is *Rs.438,795 Crores* against the backdrop of the total *Gross National Product (GNP)* of the country of about *Rs.2200,000 Crores* or more (www.indiabudget.nic.in, 2004). Over the years, more than half of the expenditure budget is spent on civil engineering works. Table 1 shows the investments made in the industry over the past years. The construction industry sets in motion the process of economical growth in the country; investment in this sector contributes *6.5%* of *Gross Domestic Product (GDP)* growth (Das, 2003). Every Re.1 investment in the construction industry causes an Rs.0.80 increment in GDP as against Rs.0.20 and Rs.0.14 in the fields of agriculture and manufacturing industry, respectively. Statistics over the period have shown that compared to other sectors, this sector of economic activity generally creates *4.7* times increase in incomes and *7.76* times increase in employment generation potentiality. Sustained efforts by the Indian construction industry and the Planning Commission have led to assigning the *industry* status to construction today. This means formal planning and above board financial planning will be the obvious destination of the construction sector in the country, with over 3.1 Crore persons employed in it.

Table 1. Investment in the Construction Industry (Swarup and Mahajan, 2001)

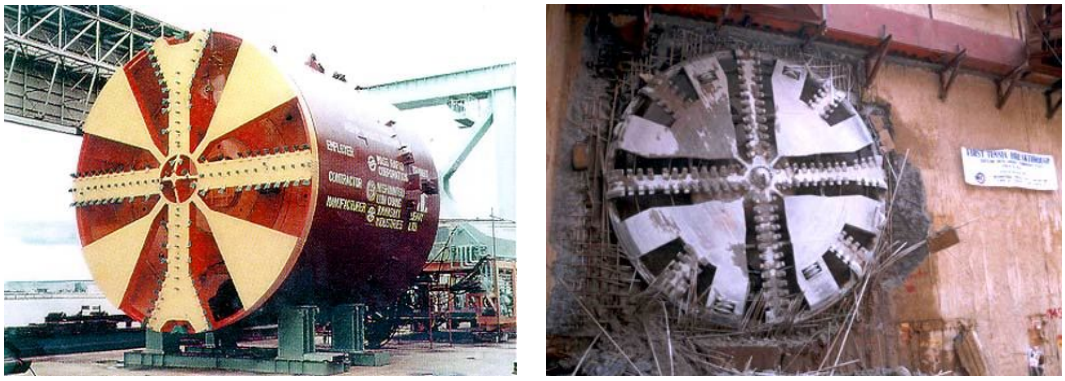
	Amount *(in multiples of Rs.100 Crores)*				
	1998	**1999**	**2000**	**2001**	**2002**
Residential Construction					
Public	43	46	65	75	77
Private	47	49	85	100	103
Total	***90***	***95***	***150***	***175***	***180***
Non-residential Construction					
Public	56	58	55	60	65
Private	104	107	95	110	120
Total	***160***	***165***	***150***	***170***	***185***
Civil Engineering Construction					
Public	1350	1480	1690	1900	2155
Private	500	530	640	755	880
Total	***1850***	***2010***	***2330***	***2655***	***3035***

2. NEW MEGA-PROJECTS

In the recent times, India has stepped up its development agenda. One explicit indicator of this is the aggressive pace of construction activity in the country. The honorable President of India, Dr. A. P. J. Abdul Kalam, has set the goal of 2020 for India to become a developed nation. However, economists and development analysts of the country have a different perception. They believe that if the current national level initiatives are consistently supported along with a few new initiatives in the areas of education, health and labour, this country will be in the driving seat and on a one-way street of growth. The particular emphasis on infrastructure development will put India on a road map with Brazil, China and Russia towards becoming a developed nation by 2050. The following are some of the physical infrastructure related projects that the country has undertaken or is poised to undertake in the near future.

2.1 Delhi Metro Rail Project

This project is developing a *Mass Rapid Transit System (MRTS)* in Delhi. The first phase of the project is presently under operation. It aims to provide *68.3 km* of *MRTS* by September 2005. The estimated completion cost of this phase alone *Rs.10,500 Crores*. It involves construction of *10.5 km* of surface lines, *45.6 km* of elevated routes and *12.2 km* of underground routes. The construction of underground segments involves tunneling through hard rock strata. Special giant-size (6m diameter) *Tunnel Boring Machines (TBMs)* (Figure 1) are being used for this (*http://irfca.org/users/delhimetro/news/may10.pdf*).



(a) **(b)**

Figure 1. Giant Tunnel Boring Machines used in underground tunneling work in the Delhi Metro Rail Project: (a) Full view on arrival at the seaport in India, and (b) a *break-through* in hard rock strata of Delhi. (Source: *www.delhimetrorail.com*)

The project will benefit wide sections of the society. Some of the more obvious benefits of this project are significant reduction in road transport, less journey time, lower consumption of fuel, reduction in atmospheric pollution, reduction in accident rates, and reduction in space requirement for traffic movement.

2.2 Highway Projects

Until recently, India lacked proper highway network across the length and breadth of the country, which severely affected the pace of growth. The development agenda of the nation and the projected industrial growth demanded world-class road network for safer, faster and efficient movement of men and material. A detailed assessment of needs was done and ambitious plans were prepared to

undertake a mega-project for highways as part of the Ninth Five Year Plan. The project comprises of two parts (Figures 3 and 4), namely:

(a) *Part I : Golden Quadrangle* – Connecting all four mega-cities of India; and

(b) *Part II : North-South and East-West Corridors* – Connecting Srinagar-Kanyakumari and Silchar-Porbandar respectively.

During 1999-2007, about *14,846 km* of 4/6 lane highways are to be built at an approximate rate of *1650 km per year* (Das, 2003).

Figure 3: Status of Golden Quadrangle as on 30 November 2003 (Source: *www.nhai.org*)

Figure 4: Status of North-South East-West Corridors as on 30 November 2003 (Source: *www.nhai.org*)

The total capital investment is estimated to be *Rs.58,000 Crores* in the Golden Quadrangle and *Rs.40,000 Crores* in North-South East-West Corridors. During 2001-04 it has been estimated that total 18 Crore man-days will be created due to this project, comprising of employment to 250,000 construction workers and 10,000

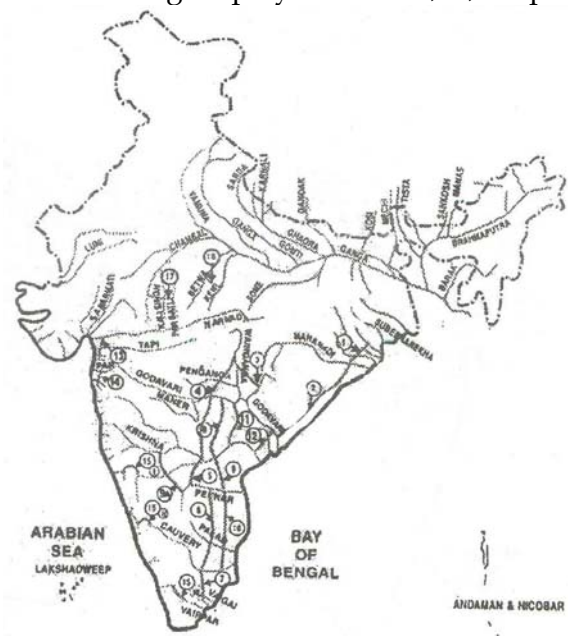
supervisory technical personnel per day. World Bank in its report has estimated that approximately *Rs.8,000 Crores* will be saved on fuel and vehicle maintenance cost every year due to high standards of Golden Quadrilateral alone.

2.3 River Inter-Linking Project

This project of developing a mega-network of canals linking major Indian rivers is a long-term, multi-Crore solutions of Country's drought, flood, inter-state water dispute, chronic power shortage and pollution. It would open-up windows of opportunities like water transport and tourism, which have ample geo-political and socio-economic benefits. The total project is expected to cost *Rs.560,000 Crores*, which is expected to irrigate an additional 15,00,00,000 hectares land (NWDA, 2003). Presently, out of the total geographic area of 32,80,00,000 hectares of the country, 14,20,00,000 hectares is irrigated. Thus, with the implementation of this project, the irrigated land in the country would double covering almost the entire nation. The project is also expected to generate *35,000 MW* of electricity. This would increase the power generating capacity of the nation by 33% of the present capacity of *104,918 MW (*www.ntpc.co.in, 2004).

The *National Water Development Agency (NWDA)*, the nodal agency to steer this project, has divided the project into two broad components, namely the *Himalayan Component* with 14 river links (Figure 5) and the *Peninsular Component* with 17 river links (Figure 6). Some obvious benefits expected from the project are:

1. Creating the potential to increase agricultural production by an additional 100% in the next 5 years;
2. Avoiding huge financial losses that result from loss of crops due to drought and flooding conditions in many parts of the country;
3. Saving *Rs.3,000 Crores* annually in foreign exchange by avoiding importing oil because of the alternative navigation provided along the coastline;
4. Enhancing national security by providing additional water-line of defense; and
5. Providing employment to 10,00,000 people for the next 10 years.



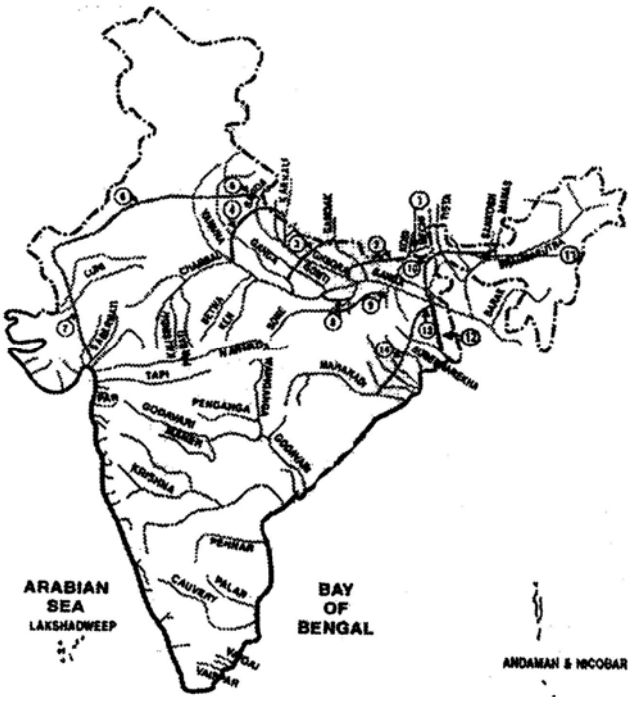
Proposed River Links

1. Mahanadi-Burhabalang
2. Mahanadi-Godavari
3. Indravati-Wainganga
4. Wainganga-Krishna
5. Krishna (Srisailam)-Pennar (Prodattur)
6. Pennar (Gandikotta)-Palar-Cauvery
7. Cauvery-Vaigai
8. Godavari (Inchampalli)-Krishna (Nagarjunasagar)
9. Krishna (Nagarjunasagar)-Pennar (Somasila)

9.A Krishna (Almatti)- Pennar

10. Pennar (Somasila)-Palar-Cauvery (Coleroon)
11. Godavari (Inchampalli)-Krishna (Pulichintala)
12. Godavari (Polavaram)-Krishna (Vijaywada)
13. Par-Tapi-Narmada
14. Damanganga-Tansa/Pinjal
15. West Flowing Rivers of Kerala and Karnataka (Bedti-Varda; Netravati-Hemavati; Pamba-Anchankovil-Vaippar)
16. Ken-Betwa
17. Parbati-Kalisindh-Chambal

Figure 5. Proposed Links of the Peninsular Component (Reddy, 2002)



Proposed River Links

1. Kosi-Mechi
2. Kosi-Ghagra
3. Gandak-Ganga
4. Ghagra-Yamuna
5. Sarda-Yamuna
6. Yamuna-Rajasthan
7. Rajasthan-Sabarmati
8. Chunar-Sone Barrage
9. Sone Dam-Southern Tributaries of Ganga
10. Brahmaputra-Ganga (Mstg)
11. Brahmaputra-Ganga (Jtf) (Alt)
12. Farakka-Sunderbans
13. Ganga-Damodar-Subarnarekha
14. Subarnarekha-Mahanadi

Figure 6. Proposed Links of the Himalayan Component (Reddy, 2002)

2.4 Sea-Ports Project

This project of upgrading existing ports along the gigantic coastline of the country will be an invitation to traders from all directions to conduct business with India; the project is therefore called as the *Saagar Mela Project* and sometimes as the *Necklace Project*. With an total outlay of about *Rs.60,000 Crores*, this project is also expected to relieve the pressure on the rail, road and air traffic systems, by allowing the ship and ferry services between various port cities. The project entails improvement of harbour structures, developing advanced navigational inventory systems for small and large vessels, and adding a few smaller ports to facilitate off-loading of cargo at points where the rail or road traffic is not already too congested.

2.5 Air-Taxi Project

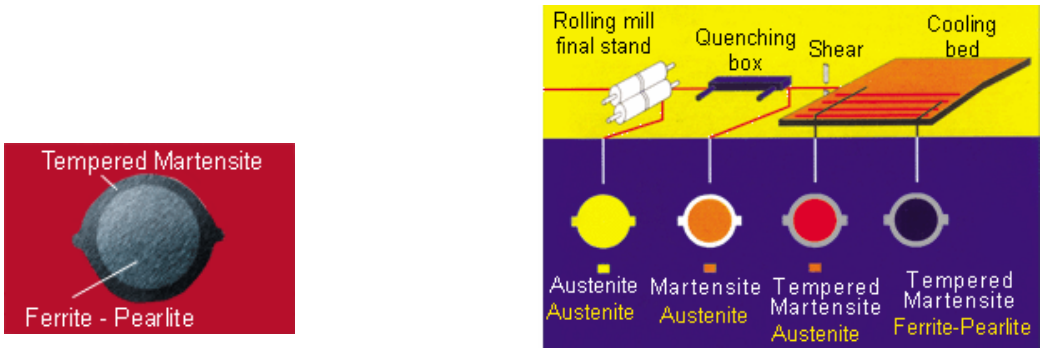
Another *mega*-project that is under plan preparation is one that will enhance air connectivity between various places in the country. It is expected that the enhancement of existing airports to higher standards and capacity, and addition of new airports at critical locations will lead to more hubs for traffic exchange, in contrast to just Delhi and Bombay currently. It is also proposed to have a high capacity airport at Nagpur, which will off load and carry passengers from any corner of the country to another such destination without having to necessarily reach one of the already busy airports of Delhi and Bombay. This project along with other national level initiatives of the Central Government is expected to result in a sharp drop (by about 70-80%) in the current air travel cost in the country. The financial outlay for this project is expected to far exceed some of the ongoing mega-projects like the *highways project* or the *sea-ports project*.

3. NEW MATERIALS, EQUIPMENT AND TECHNOLOGIES

New mega-project undertaken, involvement of international consultants, and participation of Indian consultants/contractors in international projects has led to infusion of new materials, equipment and technologies in the construction practices in India. While manufacturing of new materials is going on at a more aggressive pace, the manufacturing of new equipment is constrained by large capital investments and the uncertain markets. However, the growing market for such advanced equipment will eventually push the entrepreneurs to manufacture these also. On the technological front, the picture is abysmally low. The country has not invested adequately into making technical human resources capable of addressing the professional services needs of the construction industry like litigation, training of artisans, cost indices, contracting, insurance, finance, banking and taxation. On the engineering design front, the college education of the practicing engineers has not been adequately augmented from time to time with in-house or distance education modules. Thus, senior engineers are often found oblivious to new technologies and tools. As a consequence, the country is faced with a dire need for *qualified* technical manpower. The following are some of the newer initiatives of the construction industry in the area of materials and construction strategies.

3.1 Corrosion Resistant Steel (CRS)

This new-generation high strength ribbed reinforcement bar, was first introduced in India by m/s TATA Steel Limited, Jamshedpur. It is different from traditional bars in its method of manufacture and consequently, in its properties. CRS is produced using the *Tempcore Process*, introduced in India for the first time by TATA Steel under license from *Center de Rechaerche Metallurgiques* (CRM), Belgium – inventors of the process. The process imparts high strength to the bar using the thermo mechanical treatment (TMT) technique; this is in contrast to the cold twisting that was used in the manufacture of traditional reinforcing bars. The cross-section of bars produced by this treatment process has a strong outer layer of tempered *martensite* and a ductile inner core of *ferrite-pearlite*. The duality in the constitution gives these bars their unique combination of high strength and high ductility. These bars have additional desirable properties: no residual stress, uniform properties along the length, high bond strength (2-3 times that in mild steel bars), and superior bendability.



(a) (b)

Figure 7. Strong Outer Layer – Ductile Core of Corrosion Resistant Steel (Source: *http://www.tatasteel.com/longs/tiscon/images, February 2003*)

3.2 Closed Structurals

The structural and functional advantages of hollow sections (Figure 8) have always appealed to the engineers. Till 1959, square and rectangular hollow sections were shop fabricated by welding or jointing together structural plates and sections. This involved expensive fabrication, restricting architectural expressions to traditional steel forms. Research and development of hollow sections are carried out by an international organization, CIDECT (Headquarters: Paris). In India, TATA STEEL adopted this concept. The excellent distribution of the material around the centroidal axis of closed structurals exhibits remarkable strength qualities, and thus offers decisive advantages in its applications. Compared to conventional sections, hollow sections result in reduced use of steel (Table 2).

Figure 8. Rectangular and Square Sections (Sinha, 2003a)

Table 2: Economy of Steel Consumption through use of closed-structurals (Source: *www.tatatubes.com/frames_pages/frames_closedstructurals.htm*, 2003)

Property of Closed Structurals	Application in Structural Systems	Steel Saved compared to Conventional Sections (%)
Symmetry about all axes	Tension Ties	15
Higher Radius of Gyration	Compression Struts	45
Higher Lateral Rigidity	Flexural Members	25
Higher Shear Area	Members under Shear	40
Greater Enclosed Torsional Area	Members under Torsion	80

3.3 Pre-engineered Buildings (PEB)

These are a special class of buildings, which are constructed by assembling pre-built primary framing systems with other secondary structures and claddings (Figure 9). Various types of framing systems such as clear span rigid frames, beam and column frames, space saver frames, single slope, multi-span and lean-to frames are available depending upon the needs of the builders. They are also built to accommodate various sidewall heights, bay spacings and loading conditions. The invention of these buildings has greatly increased the speed of construction. However, concerns have been expressed over the multi-disaster resistance of these buildings. Hence, full scale testing should be conducted on them and especially on their connections to confirm their reliability in sustaining hazards.

Figure 9: A three-storey Pre-Engineered Building under construction by assembling of pre-engineered components, and in finished state. (Source: *www.hcisteel.com, 2004*)

3.4 Engineered Steel Guardrail Systems

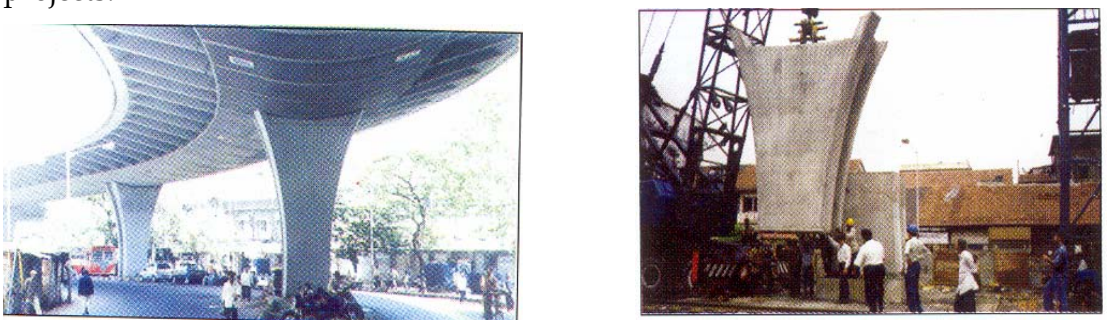
A noticeable change in the construction projects is the quantitative design of systems that were hitherto provided in a prescriptive way. The engineered steel guardrail systems provide utmost safety for vehicles and pedestrians on roads, highways and bridges. These rail systems are specially profiled with W- or 3-Beam systems (Figure 10). They are manufactured using facilities such as high precision cold forming lines, large presses, automated welding lines and complete in-house fabrication facilities ideally suitable for manufacture of high quality steel guard systems. Mainly used as medians and edges of highways and bridges, these systems are highly beneficial. For instance, they: (a) absorb impact of the vehicle and ensure minimum damage to the vehicle; (b) restrain laterally the vehicle from veering off the carriageway; (c) prevent vehicles from skidding back to the carriageway during impact; (d) provide gradual deceleration of the vehicle into the carriageway after impact thereby avoiding any risk to flowing traffic; (e) act as a visible guide to drivers during nights and bad weather; and (f) permit quick repair in case of damage due to accident.

Figure 10: Steel Guardrail Systems (Source: *www.kirby-india.com, 2004*)

3.5 Urban Construction Strategies

Large-size precast piers are used in the construction of flyovers over existing roads or other utility services that are too important to be closed or dismantled for the construction work of the flyovers (Figure 11a). These massive precast structures are erected at site with large capacity cranes that are themselves not to restrict the flow of traffic (Figure 11b). In addition, the *Indian Society of Trench less Technology (INDSTT)* introduced the trench-less pipe laying technology to assist in interruption-free construction in urban environments. Besides project design, development,

implementation and monitoring are gradually getting transferred to the computers by consultants, project owners and contractors. Some leading corporate agencies are planning initiatives for web-enabled design, control and monitoring of construction projects.



(a) **(b)**

Figure 11: Massive Pre-cast Piers used for flyovers without disruption of underlying services and utilities: (a) JJ Hospital Flyover on Precast Piers in Delhi, and (b) Transportation of Precast Piers from site of construction to erection site (Bhattacharya, 2002)

3.6 Machine Automated Slip-form Pavers

The hectic pace of construction of highways across the country and the extensive work of flyovers in the urban areas, made it imperative to use mechanized methods of pavement construction. These pavement construction machines in use are equipped with machine guidance systems that guide the pavers along the desired alignment of the pavement. These machines are fitted with tilt sensors that deliver information about the longitudinal and transverse slopes of the machines. Monitoring devices stationed on ground transmit a permanent stream of measurements by radio to the machine's on-board PC (Figure 12). The PC uses this data to calculate the machine's current position and orientation, and compares it with the project design. The resulting control parameters are then sent to the machine. The guidance system continually matches instantaneous position with the desired profile of the pavement, adjusting the height profile of the concrete as it is being laid and steering the machine in the required direction. This non-stop machine guidance accomplishes greater speed and precision than would be possible with the eye, or conventional measurement and control techniques. With the machine under automatic control, the driver can concentrate fully on the production process. Better operational safety and reliability result in greater paving speed and productivity.

Figure 12: Automatically guided slip-form paving machine and on-ground monitoring systems for transferring information from ground to machine. (Source: *www.leica-geosystems.com, 2004*).

4. PROJECT MANAGEMENT

4.1 Site Selection and Landscaping

Considered to be the first step in planning of a mega project, site selection and landscaping is also the most important step in development of any mega-project. Apart from determining the cost and completion time, it also affects the quality and overall impact of the project. Almost all the factors that contribute to the project cost depend on location of the sites, as it determines impact on environment, impact on the overall development of nearby area and impact on human/material resources (Natarajan, 2003). The main factors that influence the selection of sites for mega-projects are availability of distribution or transmission lines of electricity, availability of raw material sources and availability of transmission facilities like roads, rail, airport and waterways.

4.2 Basic Infrastructure

Multiple basic infrastructure support is needed for the development of any mega-project. These supports should be developed in parallel with the project itself as the project progresses. The major points to be kept in mind for development of basic infrastructure are water supply, power supply, roads and hospitals, entertainment and shopping facilities (Natarajan, 2003).

4.3 Contract Management

Management of contracts is one of the important aspects of construction management. Contractors engaged for the specific purpose usually execute civil engineering construction projects. Even when *large-scale turnkey* contracts of large projects are awarded to big contacting agencies, sub-contractors execute the works. In some instances, the owner of the project does not have control over these sub-contractors, as they are normally accountable only to the main contractor, resulting in delays and poor quality output.

Problems of contract management in civil engineering constructions in India can be minimized to a great extent, if management of contracts is taken up even before drafting the contract documents. In fact, this should be done while carrying out the planning and investigations of the project and estimation of items of work at tender stage. Therefore, it should be ensured that what is likely to be asked for, is possible to be performed, well before formulation of the contract documents. A good contract document should therefore have fairness or equity to either parties to the contract, clarity or un-ambiguity of all items of work, avoidance of redundancy due to lack of knowledge or in-attention to details and general and detailed specifications (Saha, 2003).

4.4 Consultancy Services

It is absolutely necessary to ensure optimum involvement of consultants in construction projects, as the decision makers cannot be master of all the jobs. A sound advice and proper guidance is required for the execution of the project in right direction. Hence evolution of a system where the contribution of the consultant is optimized and the scarce resources are utilized to their fullest potential is very important. Today, consultancy services are available in India for proper site selection, for planning and design of project, for financial resources, for legal aspects, for environmental impact assessment and rehabilitation, and for realization of

benefits of projects (Natarajan, 2003).

4.5 Project Control

Time and cost over-runs in Indian projects often discouraged owners from undertaking such projects. Control of mega-projects must be catered-for in the planning stage itself. The parameters to be measured or assessed, the method and frequency of reporting, and the levels at which corrective decisions are to be taken, should all be planned in advance (Natarajan, 2003)**.** Client owners of projects in India will benefit immensely by drawing their attention to some important aspects of project control such as:

1. *Resource Scheduling* – The completion of a construction project is mainly governed by resource constraints. It is essential to develop a systematic method for the allocation of resources when the resources are limited and conflicting demands are made for same type of resource. This can be attained through proper resource smoothing or resource leveling. Procurement of resources must relate closely to the project schedule for operations and other resources.
2. *Financial Control* – It ensures that permissible limits are not exceeded in the total estimates for each project. Expenditures or liabilities are not incurred until funds are made available. The funds should be utilized in those duly authorized projects for which they are allotted and no others. Finally, it ensures that funds allotted in any particular year are spent within limits. Therefore it is essential to maintain correct and meticulous account of expenditure and liabilities to exercise effective financial control.
3. *Budget Formulations and Periodic Review* - Determining the planned the progress of each contract along with the requirement of stores is essential before the budget projection for capital works is made.
4. *Expenditure Reporting and Monitoring* - Financial control over construction projects is exercised by all levels of engineering authorities from the expenditure return. From these returns, deviations if any, are detected by analyzing the trends of expenditure, vis-à-vis allotments. Thereafter remedial actions are initiated to ensure that the final expenditure in the financial year is contained within the budgetary allocation for the year.

5. TECHNICAL HUMAN RESOURCE and EMPLOYMENT POTENTIAL

In India, traditionally the construction industry has been labour intensive as the labour is cheap and easily available. In 1995-96, approximately *1.50* Crores people were employed in this industry which is expected to be *3.26* Crores by the year 2004-2005 (Das, 2003). There are three categories of manpower involved in this industry consisting of the artisan level, the supervisory level and managerial level. It has been observed that every *Rs.1 Crore*, investment on construction project, generates employments of *22,000* unskilled man-days, *23,000* skilled or semiskilled man-days and *9,000* managerial and technical man-days approximately. With only 3% of total teaching in the country addressing the direct needs of the construction engineering and management aspects required in the construction industry, the 14th Engineering Congress on Human Capital Development in January 2002 observed that "*in time to come, India will not have sufficient quality civil engineers even to undertake basic infrastructure work*." Urgent steps are to be initiated to reverse this trend of severe shortage of technical manpower.

6. THE CHALLENGES

The construction industry everywhere faces problems and challenges. However, in developing countries like India, these difficulties and challenges are present alongside a general situation of socio-economic stress, chronic resource shortages, institutional weaknesses and a general inability to deal with the key issues. There is also evidence that the problems have become greater in extent and severity in recent years. One of the charges leveled at the construction industry, as at the beginning of the 21st century, is that it has a poor record on innovation, when compared with manufacturing industries such as aerospace or electronics.

6.1 Housing

As per 2001 census, the total number of houses in India is 24,90,95,869, of which only 23,32,84,677 are occupied; the rest were found vacant (www.censusindia.net, 2004). However, even today, a large segment of India's population is still houseless. Three major bottlenecks in the construction of houses are (a) constraints of taking to the common-man the know-how on making disaster-resistant housing, (b) constraints of taking to the common-man the know-how of effectively using local material in house construction, and (c) inadequate finances. Notwithstanding this, the State Governments in association with the Central Government have undertaken several housing projects to provide houses to the needy. Two such schemes are:

1. *Valmiki Ambedkar Awas Yojna* – This project aims at providing shelters or upgrading the existing shelters of people living below poverty line in slums of urban areas. A grant of about *Rs.1,000 Crores* is sanctioned annually under this project. *HUDCO* and the *Ministry of Urban Development and Poverty Alleviation* jointly fund the project (www.ciionline.org, 2004).
2. *Indira Awas Yojna* – This project provides grants for the construction of houses to the people of backward and weaker sections living below poverty line in rural areas of the country. Ex-servicemen, and widows or next-of-kin of defense personnel and paramilitary forces killed in service are also included under this project. The construction assistance granted is *Rs.20,000* for each house in plains and *Rs.22,000* for each house in hilly terrains or difficult areas. The Central Government bears 20% of this cost and the State Governments take the rest (www.panasia.org, 2004).

Often, it is found that type-design houses were made with locally available materials (*e.g.,* Figure 13). This is particularly common in post-disaster reconstruction projects. For instance, the Government of Maharashtra constructed type-design houses at Vondh village (Gujarat), as a contribution to post-earthquake reconstruction after the 2001 Bhuj earthquake in Gujarat. After the reconstruction, the upper-class citizens of the village did not want to occupy the identically sized house as their lower-class counterpart in the same reconstructed village. Such significant sociological issues surfaced when the houses remained un-occupied for over a year. Intervention of non-governmental groups is desirable to sort out such issues even before the reconstruction is undertaken.

Figure 13: Single-storey housing in Vondh village (Gujarat) built by the Government of Maharashtra.

6.2 Environment

The preserving of environment is a great challenge in a developing country like India, which has a fragile environment that is faced with high levels of land degradation (*e.g.,* erosion, aridity, desertification, drought, flooding, and alkalinity and salinity of ground). The rapid urbanization alongside associated problems like pollution of air and pressure on existing infrastructure with regard to waste management, pose a race against time. Many countries, mainly industrialized ones, have taken steps to ensure that the reduced use of construction materials, techniques and practices, which result in operations and products that have lower environmental impact (Aggarwal, 2003). Developing countries like India can derive valuable lessons from these steps. Some of the desirable steps are:

(a) *Government action* – The Government need to enforce legislation and regulations on environmental performances. Licenses and approvals need to be regulated with transparency to ensure that all organizations in the industry operate in an environment friendly manner. Tax holidays and special grants may be introduced to encourage environment protection. A policy of certification and labeling of products need to be brought into practice.

(b) *Market forces* – Project clients need to insist on better environmental performance of construction companies. Experience from other construction firms adopting or benefiting from good environmental practices need to be disseminated to all.

(c) *Institutional initiatives* – Professional bodies need to take interest in providing support services to construction firms to function in an environment friendly manner.

(d) *Operational environment* – Pressure groups and informed users need to work continually to prevent deterioration of the environment.

The practice of being engaged in a continuous search for inputs and ways of working which will minimize the negative impact of construction activity on the environment should be encouraged among construction companies and practitioners. Also, openly discussing detailed case studies of good practices would be useful. The feasibility of preparing good-practice manuals suitable for use in various contexts may be investigated.

6.3 Transportation

The National Highways Development Project (NHDP) aims at 4/6 laning of about *14,846 km* of National Highways in the country between 1999 and 2007. Apart from the stringent physical targets, which are perhaps unparallel in the history of highway construction, the cost of the Project is huge – about *Rs.54,000 Crores* at 1999 prices. This amount was required over a period of 9 years from 1999-2000 to 2007-08 with peaks reaching up to *Rs.10,000 Crores* in mid-period (Sinha, 2003b). Historically, development of National Highways road infrastructure was financed from the budgetary allocations of the government. But, these were of the order of only *Rs.2,000 Crores*. Thus, financing of NHDP was not possible from budgetary source and some innovative financing mechanism was necessary. Hence, a time-plan for financing was developed for the project (Table 3).

Table 3. Financing Plan for NHDP (Sinha, 2003b)

Sources	**Amounts (Rs. Crores)**
Cess Accruals	20,000
Loan Assistance from International Lending Agencies	20,000
Private Sector Participation	4,000
Market Borrowing	10,000
Total	**54,000**

The project also required extensive transportation planning so that optimum benefit may be obtained from it. Since the project extends over the entire country, it will involve construction in extreme hot and cold climates as well as in highly humid weather in different locations. Standardized materials and design mixes became necessary in the construction of these pavements, in stretches. In areas regions of high temperatures, problems of bleeding and flowing of bitumen are common, which thereby leads to the routing of the pavements. Hence, high grades of bitumen are being used in this type of construction to minimize this problem. Construction of roads in very cold climatic conditions requires large amounts of fuels for melting the bitumen. A remedy for this is obtained through the use of *emulsified bitumen*, consisting of fine globules of bitumen suspended in water. After the bitumen is laid and settles down, the water evaporates. Humid climate causes reveling of pavements due to the combination of moisture with bitumen, which exposes the aggregates on the surface of pavements. Here, aggregates are being used in surface-dry condition.

Presently, locally available aggregates that marginally fail in the test results also are being used. They are being used in cemented base along with cementitious materials such as fly ash or other puzzolanic materials, thereby enhancing the use of locally available materials for highway construction to a great extent. Stringent quality control measures and R&D effort to enhance such locally available material for use in construction need to be stepped up. In many situations highway construction involves widening of existing roads. Strategic planning is required to ensure minimum disruption of traffic on the existing roads alongside enhancing the speed of construction. Equipments and procedures to measure the density of the finished pavement layers are as important to be checked as the thickness of the

pavement. Such facilities need to be put in place. Also, robust statistical quality control recommendations are also essential for the various on-site measurements.

6.4 Power

As per the 2001 census, 57.3% houses in rural areas and 12.4% in urban areas of India do not have electricity and rely on other sources for lighting. Nowadays, large apartments and multiplexes in big cities are being built with captive power generating units. These self-sufficient of power generating systems are being insisted by the Municipal Corporations at the time of providing clearance to such high-budget projects (Figure 14).

Figure 14: Large apartments and commercial complexes with captive power generating systems (Source: *www.unitech-limited.com*)

6.5 Natural Hazards

India as a nation is quite susceptible to all forms of natural hazards. Of all these, floods happen to be the most frequent form of natural disaster faced by the country. It has *40 million hectares* of flood prone lands and on an average *18.6 million hectares* of its land is flooded annually (Figure 15) (www.rrtd.nic.in, 2004). Earthquakes cause the most dangerous and most devastating natural disasters in India. Over *60%* of the land area of the country is vulnerable to earthquakes of moderate to severe seismic intensities (Figure 16). Also, the Indian Ocean is considered to be the six most cyclone prone areas of the world. This exposes the *8,040 km* long coastline of the country to tropical cyclones (Figure 17). Natural Hazards like earthquakes, floods and cyclones always lead to immense damage and widespread destruction of civil engineering structures.

The financial setback in such disasters is huge. Further, the rehabilitation work involved after any such hazard, to bring life back to normalcy, is itself a great challenge for the construction industry. This apart, even the various equipments of the construction industry serve a great purpose in the rescue and relief works succeeding any such calamity. Undertaking detailed damage investigation, evolving appropriate rehabilitation techniques or even clearance of debris of destructed buildings requires use of specialised technology and equipment. It is therefore imperative to attempt to make only disaster-resistant constructions to begin with. Also, the governments and local bodies need to develop capacities to cope with natural disasters to mitigate the effects of the natural disasters.

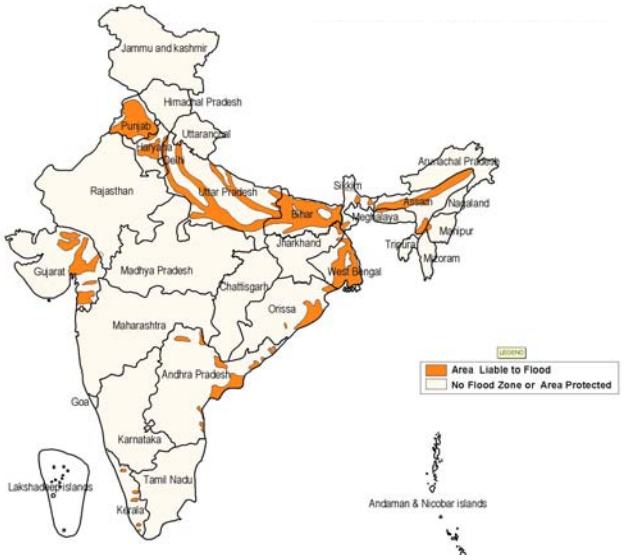


Figure 15: Flood Affected Areas of India (Source:www.bmtpc.org/disaster.htm,2004)

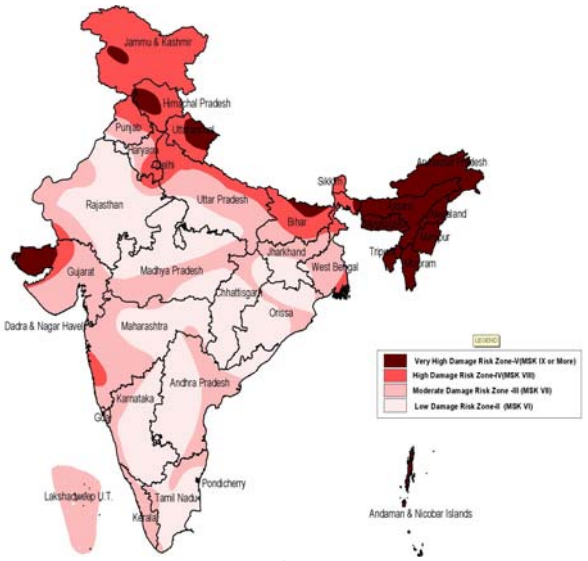


Figure 16: Earthquake Zones of India (Source: www.bmtpc.org/disaster.htm, 2004)

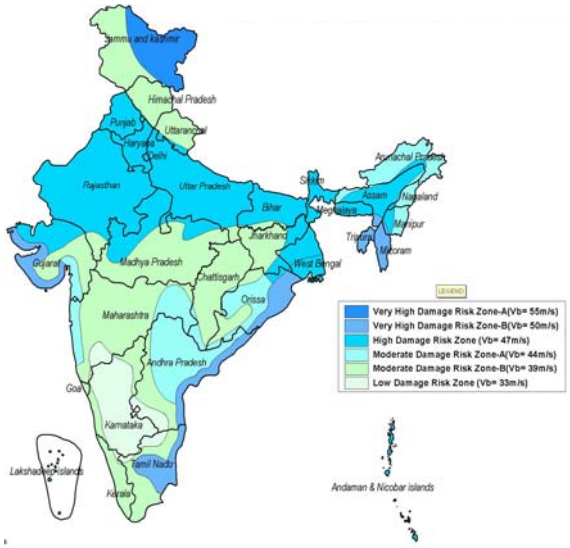


Figure 17: Wind and Cyclone Zones of India (Source: www.bmtpc.org/disaster.htm,)

7.0 CONCLUDING REMARKS

In the years ahead, the construction industry in India has to overcome various challenges - be it with respect to housing, environment, transportation, power or natural hazards. Technocrats associated with the Indian construction industry need to employ innovative technologies and skilled project handling strategies to overcome these challenges. The outstanding performance under demanding situations in the past will stand in good stead and give confidence to the Indian construction industry to bring about an overall development in the infrastructure of the nation. The gains of large investments in the mega-projects eventually will feedback to the construction industry itself in the form of better economy and improved work conditions.

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