ADVANCES IN CIVIL INFRASTRUCTURE ENGINEERING

Cheemalakonda Ramakrishna

Guide: Mr. Chitranjan Kumar, Assistant Professor

Master of Technology in Structural Engineering

School of Engineering and Technology,

Shri Venkateshwara University,

U.P, Gajraula-244236

ABSTRACT

Infrastructure is defined as the basic physical systems of a business, region, or nation and often involves the production of public goods or production processes. Examples of infrastructure include transportation systems, communication networks, sewage, water, and school systems. Investments in infrastructure tend to be costly and capital-intensive, but vital to a region's economic development and prosperity. Projects related to infrastructure improvements may be funded publicly, privately, or through public-private partnerships. Civil infrastructure plays a pivotal role in societal development. Buildings, bridges, dams, tunnels, roads, railways, and airfields are essential assets that contribute to the well-being of communities. However, these infrastructures face significant challenges, including exposure to natural forces and environmental degradation. As climate change intensifies, extreme events become more frequent, impacting society and emphasizing the urgency of sustainable solutions. In response, civil engineering continues to evolve, addressing emerging needs. Researchers, professionals, and students contribute to advancements in this field. Notably, green and intelligent technologies promote sustainability and resilience, mitigating environmental and social impacts. Infrastructure is the basic facilities and system serving a country, region, or community. Examples of infrastructure include mass transit and telecommunications networks. Large-scale infrastructure is usually produced by the public sector and funded by revenue. Infrastructure can often be produced on a smaller scale by private firms or through local authorities. Infrastructure can be classified as soft or hard and both are essential to the economy and quality of life of a society. Infrastructure is one of the most crucial pillars of productivity in any economy. Pushing infrastructure development and particularly organizing funds for infrastructure projects have been the biggest challenge in developing nations. The present study was taken up to review the infrastructure development and its financing in India. The study intended to 1. Study the infrastructure development in India in the 11th and 12th Five Year Plan, 2. examine the sources used for infrastructure financing in India, 3. Assess the actions taken by government to facilitate infrastructure financing and 4. Propose measures to augment infrastructure financing to overcome infrastructure deficit in the country. It was found that though Government of India and Reserve Bank of India have taken several initiatives to facilitate infrastructure financing, there still exists a vast gap between supply side and the demand side. Some of the recommendations given in the paper include the need to evolve innovative business models and mitigate administrative glitches to ensure larger private participation; exploit the untapped potential of diaspora; revisit the statutory liquidity ratio norms for banks; evolve the municipal bond market; boost regional integration and improved connectivity through creation of corridors between sub-continental regions, which would not only bridge the finance gap but also the knowledge gap, etc.

CHAPTER 1

1.0 INTRODUCTION

The term infrastructure first appeared in the late 1880s, derived from French, with infra- meaning below and structure meaning building. Infrastructure can mean the foundation upon which the structure of an economy is built. Infrastructure includes a variety of systems and structures where physical components are required such as the electrical grid across a city, state, or country. While the facilities, equipment, or similar physical assets like bridges and roads are essential to an economy, infrastructure also enables citizens to participate in the social and economic community and provides them with necessities such as food and water. Because infrastructure often involves the production of either public goods or goods that lend themselves to production, it is typical to see public financing, control, supervision, or regulation of infrastructure. This usually takes the form of direct government production or production by a closely regulated, legally sanctioned entity. The first federally funded infrastructure project was the Cape Henry Lighthouse, built in 1789 at Virginia Beach, Virginia. Sometimes private companies choose to invest in a country's infrastructure development as part of a business expansion effort. For example, an energy company may build pipelines and railways in a country where it wants to refine petroleum and this investment can benefit both the company and the country. Individuals may also choose to fund improvements to certain pieces of public infrastructure. For example, an individual may fund improvements to hospitals, schools, or local law enforcement efforts.

1.1 Types of Infrastructure

Infrastructure is often categorized as hard or soft. Hard infrastructure is the tangible, physical assembly of structures such as roads, bridges, tunnels, and railways. Soft infrastructure is the services required to maintain the economic, health, and social needs of a population.

Hard Infrastructure

Hard infrastructure is the physical system needed to run a modern, industrialized nation. Examples include roads, highways, and bridges, as well as the assets required to make them operational such as transit buses, vehicles, and oil refineries. Technical systems such as networking equipment and cabling are considered hard infrastructure and provide a critical function to support business operations. According to the Brookings Institute, 14 million people have jobs in fields directly related to infrastructure. From locomotive engineers and electrical power line installers to truck drivers and construction laborers, infrastructure jobs account for nearly 11% of the nation’s workforce.

Soft Infrastructure

Soft infrastructure represents human capital and institutions necessary to maintain an economy that delivers certain services to the population such as healthcare, financial institutions, government offices, law enforcement, and education. Investments in soft infrastructure target how people thrive and participate in daily life.

1.2 Maintaining Infrastructure

How infrastructure is maintained and funded generally depends on who owns it. The government owns a lot of infrastructure for transportation, water, and public education. Most infrastructure is owned by state and local governments, often partially supported through federal subsidies, and some infrastructure may be entirely privately owned. Infrastructure powers businesses and connects workers to their jobs and citizens to

opportunities for healthcare and education. It creates opportunities within communities and an economy needs reliable infrastructure to connect supply chains and move goods and services.

1.3 Infrastructure Development in India

The Indian economy exhibited pliability and strength by registering 7.2 per cent GDP growth during 2015–2016. With the reforms process gathering momentum, it was expected that the yearly growth of real GDP would range between 7 and 7.5 per cent (Ministry of Finance, 2016). Christine Lagarde, IMF Chief, said that when the majority of the economies across the world were struggling with low GDP growth, India attained growth of 7.3 per cent in GDP in 2014 (World Bank, 2015b). She also said that projections showed that India's GDP is anticipated to surpass that of Germany and Japan aggregated in 2019. Estimations also hinted that India will grow to US$200 billion economy in not more than 20 years and its proportion in world economy might increase to approximately 9 per cent from being less than 3 per cent at current (Christine, 2015). Nonetheless, the gap in India's infrastructure is undisputable. According to the Global Competitiveness Report 2014–2015, India is placed at 87 among 148 countries for its infrastructure. In India, roughly 67 per cent of cargo and 85 per cent of people are transported through the roads. Humungous investments in infrastructure are the need of hour. The total capital outlay in infrastructure, which was approximately 5 per cent of the GDP in the 10th Five Year Plan and 7 per cent of the GDP in the 11th Five Year Plan, was anticipated to increase to approximately 8 per cent in the 12th Five Year Plan. The McKinsey Global Institute (2013) projected that if the outlay in infrastructure increased by 1/100th of GDP, it will result in added 3.4 million jobs in India. The current study brings to light the infrastructure development in India during 11th Five Year Plan (2007–2012) and the first half of the 12th Five Year Plan (2012–2017) and discusses the targets and the total capital outlay earmarked for the coming years to minimize the infrastructure deficit in the country.

1.4 Infrastructure and Its Components.

a. Roads

India's road system comprises of national freeways, state freeways, district roads and rural roads. According to the 12th Five Year Plan, the national highways of 76,818 km constitute 2 per cent of the country's road network, but they transport 40 per cent of the road traffic. The state highways and major district roads together constitute 13 per cent of the country's road network, transports another 40 per cent of the road traffic. Out of 76,818 km of national highways, approximately 23 per cent is four-lane (and above average), 54 per cent length is two-lane (average) and 23 per cent length is single lane (below average).

According to Basic Road Statistics (Ministry of Road Transport & Highways, 2012), the total surfaced road in the country as on 31 March 2012 was 55.46 per cent which comprised of National Highway of 76,818 km of which 100 per cent was surfaced road; State Highway of 164,360 km of which 99.14 per cent was surfaced road; Urban Roads of 464,294 km of which 73.04 per cent was surfaced road; Rural Roads: 1,938,220 km of which 47.97 per cent was surfaced road; Other Roads 1,747,864 km of which 75.97 per cent was surfaced.

According to the availability of roads per unit area, the road length per 1,000 sq. km grew from 1,288.74 km in 2007–2008 to 1,480.07 km in 2011–2012. Infrastructure Statistics (2014) showed that as on 31 March 2012, the road length per 1,000 sq. km was 1,480.07 km—in urban areas, it was 5,940.05 km and in rural areas, it was 621.58 km. The estimates also showed that the road length per 1,000 population was 4.03 km—in urban areas it was 1.27 km and in rural areas it was 2.3 km. Under 12th Five Year Plan, the budgetary support for national highways is INR 1.44769 trillion and for rural roads is INR 1.26491 trillion. The sector is estimated to generate Internal and Extra Budgetary Resource (IEBR) of INR 0.64834 trillion and attract private outlay of INR 2.14186 trillion during the said period. With a government outlay of INR 11.4 trillion for the 12th Plan period, physical

targets of road development (both freight and passenger traffic capacity) are targeted to be more than 1.5 times the achievement during the 11th Five Year Plan.

b. Ports

Ports facilitate coastal transport and international trade connectivity which is very crucial for economic growth. Ports consist of docks where ships anchor, while loading or unloading cargo. In India, ports are classified into two categories: major ports (controlled by Union Government) and non-major ports (controlled by State Governments/Union Territories). As on 31 March 2012, India had 12 main ports and 200 non-major ports. Usage of water transport enhanced between 2007 and 2012 total cargo moved grew from 72.6 billion tons in 2007–2008 to 91.4 billion tons in 2011–2012 while the aggregate passenger traffic grew from 1.66 billion in 2007–2008 to 2.14 billion in 2011–2012 (Infrastructure Statistics, 2014). During 11th Five Year Plan, an investment of INR 55.66 billion was made to augment the cargo handling capacity at various ports and a capacity addition of 185 million tons per annum (MTPA) was achieved. Government of India in the 12th Five Year Plan proposed to invest INR 737.93 billion on ports and the capacity of major ports is expected to be increased to 1,229 MTPA (NMDP, 2012). India experienced a steady decline in shipping. India's overseas trade which was approximately 32 per cent in 1999–2000 to come down to approximately 14 per cent in 2004–2005 and further reduced to approximately 8 per cent in 2010–2011. During the 11th Five Year Plan, the shipping industry saw an increase in fleet from 787 vessels increasing to 1,135 vessels and the total cargo being shipped increasing from 8.6 million gross tons to 11.03 million gross tons, making India rank sixteenth in the world (12th Five Year Plan).During the 12th Five Year Plan, the target is to increase the capacity to 12.4 million gross tons. To accommodate the estimated traffic of 1,758.26 million tons by 2016–2017, the total capability of the port sector is envisioned to be 2,289.04 million tons. The 11th Five Year Plan had a projected capital outlay of INR 303.23 billion for shipping sector; however, only 58.3 per cent came through. The 12th Five Year Plan targeted investment of INR 289.50 billion in shipping sector. The private sector is expected to invest nearly INR 1.7 trillion in the ports (Infrastructure Statistics, 2014).

Fig 2 Ports

c. Railways

Indian Railways have a large network comprising of total tracks of 113,994 km—broad gauge 102,680; meter gauge 8,561 km and narrow gauge 2,753 km. 21,034 km is operated through electricity. Indian government added 11,864 km of new railway tracks ever since independence, which is far inadequate to handle the present passenger load and the cargo volumes.

The average number of passenger trains operated daily was 10,385 in 2007–2008 which increased to 12,335 in 2011–2012. In 2007–2008, the average number of passengers carried daily was 17.88 million which increased to 22.5 million in 2011–2012 (Infrastructure Statistics, 2014; Ministry of Railways, 2012). Railways also upgraded the quality in terms of increase in electrification of rail track and change of narrow and meter gauge into broad gauge. The proportion of broad gauge increased from 81 per cent in 2007–2008 to 87 per cent in 2011–2012. But it is pitiful that the average speed of goods trains is 25 kilometers per hour which is almost 1/2 that of the USA. The expansion of the railway network is hugely inadequate. The 12th Five Year Plan estimated public sector investment of INR 5.192[illegible]lion.

d. Civil Aviation

Civil aviation is also an essential engine of growth and development. The total of operative airports increased from 109 in 2007 to 120 in 2012. Average number of flights handled daily grew from 2,931 to 3,385 and average number of passengers handled daily improved from 2.4 lakhs to 3.3 lakhs during 2007–2008 to 2011–2012, indicative of surge in airport congestion (12th Five Year Plan). Air transport has displayed a prominent growth in availability, in terms of number of carriers and accessible seating kilometers. During 2006–2011, the passenger handling capacity augmented from 72 million to over 220 million and cargo handling capacity improved from 0.5 million tons to 3.3 million tons. According to the Report on Traffic Handled at Airports 2011–2012 (Airports Authority of India, 2012), the total travelers handled 52.947 billion; cargo transported 2,279,990 tons (Infrastructure Statistics, 2014).As per the investment plans of the airline operators, the passenger capacity is expected to increase to 370 million by 2017. Present growth in cargo will necessitate investment in specialized cargo terminal and equipment. Independent estimates suggest an additional requirement of about 180 operational airports over the next 10 years. Indian airports would require an investment of about INR 675 billion during the 12th Five Year Plan to meet the traffic growth forecasts, of which the private sector is likely to contribute around INR 500 billion (12th Five Year Plan).

e. Urbanization

Increase in urbanization is posing huge stress on existing infrastructure. Census 2011 revealed that about 31 per cent people lived in urban regions and contributed 63 per cent of the GDP. It is anticipated that by 2030 urban regions will be housing 4/10th of total populace and will contribute 3/4th of India's GDP (Ministry of Urban Development, 2014). The announcement of 'Smart Cities' by the Modi Government emphasized the necessity for an all-inclusive growth of physical, social, official and economic infrastructure for enhancing the life quality. The mission envisaged developing of 100 smart cities during 2015–2019. The Government also announced 'Atal Mission for Rejuvenation of Urban Transformation' (AMRUT) for the modernization of 500 cities and 'Sardar

Patel Urban Housing Mission' (Khan, 2015).The Modi government has allocated US$150 billion to the 'Smart City' initiative. In consultation with consortium of national and international consultants, the government would be identifying 100 cities and each selected city would receive a grant INR 1 billion (US$15.7 million) per year for over a five-year period. Government in January 2016 declared the names of the initial 20 cities which would be developed into Smart Cities. In terms of population, these 20 cities house 35.4 million people and these cities would have a total investment of INR 508.02 billion during the five-year period.

CHAPTER 2

2.0 LITERATURE REVIEW

Infrastructure plays a crucial role in facilitating high economic growth. The effect of infrastructure outlay and its quality on economic development have been extensively studied and well recognized (Calderón & Servén, 2004). Roller and Waver man (2001) found the proof of strong positive causative linkage between telecommunications infrastructure and economic growth. Calderón and Servén (2003) conducted a study in the Latin American countries and found encouraging and noteworthy output contribution of transport, telecommunication and power. Donaldson (2010) used Indian data from 1870 to 1930 and found that railroad development resulted in reduction of the cost of trading, boosted the overall trade and augmented the real income. Mohammad (2010) found that the improvements in the basic infrastructure boosted growth in production. Agénor and Moreno-Dodson (2006) and Canning and Pedroni (2008) observed that despite substantial variations across countries, the infrastructure certainly contributes to economic growth in the long run. Though the correlation between economic growth and infrastructure is complicated (Fay, Toman, Benitez, & Csordas, 2010), it is an accepted fact that the expenses in creating new infrastructure have positive correlation with productivity and progression (OECD, 2007). Even though there are wide-ranging benefits of infrastructure outlay, there is a stark shortage in the capital outlay in the new infrastructure globally (Asian Development Bank, 2009; OECD, 2007). According to Bhattacharya, Romani, and Nicholas (2012), many emerging markets, especially the low-income countries need essential measures to escalate their expenditure in infrastructure development, in order to accommodate rising urbanization and promote inclusive growth. The requirement of enormous capital expenditure coupled with the fiscal imperatives in the developing countries necessitates the private organizations to take a greater part in financing infrastructure.The fact that infrastructure and finance are the lifeblood of any economy needs no reiteration. Inadequate infrastructure is the biggest constraint in growth and development of Indian economy. To attain the predicted growth rates, India needs to develop robust infra-system. India is facing huge funding gap, which needs to be reduced. Issues such as problem in clearances, difficulty in land acquisition, delay in decision-making, pricing model of infrastructure projects; inadequate dispute resolution mechanism, etc. need to be addressed, to make infrastructure a lucrative investment.

There is also a need to create a facilitating atmosphere and set up suitable protections to encourage bigger participation by the private organizations in infrastructure projects. An elementary prerequisite for advancement of investment in infrastructure sector is a favorable policy environment, helpful in appealing private and overseas investment, while shielding community welfares and benefits.

In infrastructure financing, the problem is not that of inadequate savings, but rather deficiency of adequate financial intermediation, proficient in channelizing and mobilizing domestic savings into infrastructure sector. In the last few years, the policymakers have taken numerous measures, such as introduction of PPP model in infrastructure sector, facilitating bank financing to infrastructure sector, stimulating bond markets as alternate source of funding and creating novel and advanced channels of funding, to boost infrastructure financing. However, the regulatory and investment guidelines need further restructuring so that there can be larger scope to

promote resilient financial system with diverse investors, innovative financial instruments, alongside liquidity and depth to support long-term funding.

India at present has the highest lending rate among the BRICS nation. The ability to meet infrastructure investment target of US$1 trillion critically depends on (a) the state's capability to make the bond market popular as an alternative source to bank credit and (b) their capacity to bring about financial consolidation and decreasing upward pressure on rates of interest.

According to Ministry of Overseas Indian Affairs (2015), there are approximately 28 million Indians living abroad. Hence, there is a huge untapped potential of diaspora finance for infrastructure development in the country. Since the diaspora savings are mostly locked up in low-yielding bank accounts in the host countries, offering an annual interest rate of 4 or 5 per cent, the Government and reputed private companies can resource the wealth from migrants by selling diaspora bonds offering attractive interest rates. These bonds will also arouse emotional appeal to the NRI to make their valuable contribution in the development of their homeland. Diaspora finance would potentially help in lowering the cost of financing for development projects back home.

Banks have for long played a vital role in infrastructure financing. The credit exposure of banks is stretched to optimal level. Their balance sheet size, growth in non-performing assets and absence of motivations to advance to infrastructure sectors hugely restrict further credit expansion. It is advisable that banks should raise additional capital, by injecting Tier II capital and divestment of government stake, to avoid sector concentration. The mergers and consolidation in banking sector can diminish exposure constraints. The banks should finance the construction and the initial operation period of the infrastructure project, with insurance and pension funds providing the refinancing of bank loans over a long period, this would address the issue of asset–liability mismatch faced by banks. The Indian practice of applying CRR or SLR to 'NDTL' is not in corroboration with the global trends. Currently, the developed countries do not impose SLR requirements for prudential purpose. In the developing countries, the liquidity requirement applicable on time deposits is usually lower than on demand deposits. Some developing countries have SLR rate of less than 17 per cent for liabilities having a maturity period of less than one year and zero for liabilities having a maturity of over one year. Keeping in mind the dual aim of maintaining liquidity for premature withdrawals and compliance of the monetary policy, it is desirable that the application of CRR should be confined to cash and cash-like instruments, which include demand deposits and deposits with no minimum lock-in period. The requirement for SLR should be phased out, in view of Basel II norms, which are characterized by stern asset classification, capital adequacy and provisioning standards and guidelines. The Basel II norms appropriately ensure that the financial intermediary has sufficient liquidity to service its fixed-time liabilities. Another preposition which the banks can try using is use inter-bank operations to manage day-to-day liquidity, treat savings account balances as long-term funds.

According to Niti Ayog (2015), during the 12th Five Year Plan period, there has been drastic fall in the private investments in the infrastructure sector in the country. It is necessary to

1. re-design the 3P models to rationalize the distribution of risk and reward among the different stakeholders,
2. put in place adequate and effective dispute resolution mechanism,
3. open railways, ports, renewable energy sectors for 3P,
4. design a broad National PPP policy explaining the aims, scope and executing principles of the PPP program envisioned by the state,
5. develop e-due diligence system, to ensure faster clearances,
6. greater transparency in screening process,
7. speedy update of changes made in policy and accessibility to vital data and publications,
8. new 'go-to-market' channels and
9. investment insurance for infrastructure investment projects, to restore private interest in the infrastructure sector. Government needs to offer incentives such as reductions and exemptions in taxes (exemption of tax levied on capital good required in the infrastructure sector, fractional VAT reductions when project gets completed, etc.); capped public guarantees (minimum revenue guarantee, guarantee for buyout, etc.); rewards and bonuses (for timely/prompt completion, for avoiding cost over-runs) and compensation for losses arising due to exchange

rate movements. It is necessary that incentives or subsidies should be made conditional on social inclusiveness. A set of principal quantifiable impact pointers/indicators should be developed. State also needs to look into diverse models of PPPs such as Design and Build, Finance Only, Operation & Maintenance Contract, Build-Finance, Design-Build-Finance-Maintain, Design-Build-Finance-Maintain-Operate, Build-Own-Operate, Transfer-Operate-Transfer and Build-Lease-Transfer, etc., used across the world, to accelerate infrastructure development in the country.

In several nations, sub-sovereign bonds or municipal bonds constitute a major portion of infrastructure finance. Whereas in India, the municipal bond market is still untapped. It is essential that local governments should act as major drivers in infrastructure development of the country. There is a need to empower the local governments by granting them greater economic autonomy to raise funds for investment in infrastructure projects, with specified ceilings and subject to control measures, making them directly accountable for borrowing and repayment. Local governments use Local Government Financing Vehicles (LGFVs) to circumvent budgetary constraints and leverage their capital base. They can issue 'revenue bond' (in this interest is paid out of anticipated cash inflows), 'common bonds' (they help in funding non-income-generating capital outlays), 'direct pay bonds' (taxable bonds for which interest expense is directly subsidized by the federal government) to finance infrastructure projects. SEBI has set up a framework for issuing and registering of debt instruments by local municipal bodies, but there is a need for fine-tuning those regulations. Combined efforts are obligatory on part of Central Government, State Government and the Municipal Bodies for developing a more reliable municipal bonds market. Measures required to strengthen the municipal bond market in India include

a. revamping of regulatory framework,
b. flexibility in determining interest rate by relating it to a standard market rate,
c. provision for tax-exempt municipal bonds,
d. insulation from interventions,
e. need for credit rating,
f. need for partial or full assurance by Central/State government,
g. requisite for complete disclosure,
h. inbuilt mechanism to hedge risk for the investors and
i. expands the investor base by allowing NBFCs, Pension and Provident Funds and Foreign Portfolio Investors to invest in the securities of Urban Local Bodies and Municipal Bodies.

The depository profile of Insurance Companies, Pension and Provident Funds and Post Offices are more in harmony with the currency requisite of infrastructure. Due to the basic nature of their liabilities, they can invest for long terms and do not confront the issue of asset–liability mismatch. However, presently these institutions have subdued participation in infrastructure financing. There is a need to suitably modify their exposure limits to the infrastructure sector by approving investment in

a. AA-rated instruments (so-called 'not permitted' investments) and
b. infrastructure projects having assurance from state. India has the fastest rising middle class; however, only a small percentage of its population is investing in insurance and pension products. There is a need to announce proper schemes and appropriate incentives in insurance and pension domain, to generate additional long-term funds for infrastructure investments. Privatization of the pension system can be a significant stimulus to the development of the fixed-income securities market. Government needs to announce and promote privatized pension system in the country where contributions to pension funds are made automatically out of the monthly salary and another portion the workers are given stock/bonds in proportion to their contribution to the public system. At the time of retirement, the workers are only allowed partial withdrawal, with a substantial portion of their account to be converted into an annuity indexed to inflation. The annuity requirement would lead to substantial growth in country's retirement program and eventually give way to new fund provisions for infrastructure sector. The savings deposited in the various schemes offered by Post Offices also need to be diverted into the investment in the infrastructure projects.

There is a need for well-developed corporate bond market to provide additional funding to infrastructure

companies. It is necessary to design framework to enable lenders convert debt into equity in defaulting companies; reform pay and performance structures; devise innovative rating procedures that reward long-term investment in infrastructure sector; encourage innovative financial instruments; relax new foreign portfolio investors rules by eliminating paperwork for entities regulated by foreign securities market regulation; reduce withholding tax and provide tax shield in infrastructure bonds, for boosting investment in infrastructure. The investment bankers can act as bridge between the state and the private organizations by providing innovative financing solutions. They can do underwriting of the new issues offered by private companies, semi-government entities such as municipal bodies for financing infrastructure projects. There is a need to develop derivatives markets, particularly for interest rates and foreign currency. Indian public utility companies with investment-grade ratings and implicit sovereign guarantees should be allowed to issue foreign currency shares, bonds, ADRs, GDRs and hybrid instruments in overseas markets, but the financial risks will have to be judiciously observed and managed.

Participation of private entities in infrastructure financing will largely depend on the nation's capability: to develop well-organized debt market, making regulatory transformation which facilitates diversification and removing the hurdles for overseas investors. ECBs for infrastructure are inadequate due to

a. poor balance sheets of infra-companies and absence of creditability,

b. interest rate caps,

c. restriction on foreign participation and

d. limited hedging possibilities. Another impediment in exploiting foreign funds is the absence of adequately profound forwards market in foreign exchange.

Government should promote intra-regional infrastructure development, i.e., regional integration and improved connectivity through creation of corridors between sub-regions. This would accelerate infrastructure development, attract new investment and stimulate economic development. For this, it is essential to create synergies and to ensure policy coherence. It is important that there is some common parlance and linkage between the micro and macro policies, between investment and sustainable development strategies and between national and international investment policies. Partnerships between home countries of investors and host countries, trans-national corporations and development banks can assist in reducing information gaps and create united investments in infrastructure sector.

CHAPTER 3

3.0 ADVANCES IN CIVIL INFRASTRUCTURE

3.1 Advances in construction of roads

While an efficient transport system is needed for growth of economy, roads play an important role as most sought mode of transport. India has an extensive road network of 4.6 million kms and number of vehicles are growing at almost 10% per annum in last 5 years with overloading and growing traffic stressed road infrastructure. To cope up with increasing transportation demand, in the immediate next following decades, newer and different transportation systems will be greatly encouraged; however, road transport will continue to play a major role. As this new regime approaches and the earlier methods tend to become unacceptable, labor and labor-intensive techniques will experience shortages. In addition, the world is facing acute shortage of naturally available ingredient materials and the cost of construction materials increasing every year; the situation is forcing the agencies to find alternate sources and materials. Also, design, materials, and workmanship, will have to provide a long-lasting product to avoid the need for major traffic disruptions for maintenance and rehabilitation or reconstruction, keeping in mind the health and safety issues as well. This scenario demands new techniques, construction-automation and equipment, so that equivalent work can be performed with fewer crew. The automation is likely to prove more reliable, efficient, and cost-effective as well. Road pavements and allied structures, thus, are expected to undergo significant changes in terms of materials and methods of construction operations.

A pavement structure, understandably, is interposed between the wheel and ground (soil), to support and sustain the repeated applications of wheel loads without undergoing undue deformation. The roadway structure is, thus, expected to be stable and non-yielding to generate only least possible rolling resistance for the heavy wheel loads. The pavement is made of higher quality materials, though, the strength of materials of different layers differs with a more specific functional attribute. Based on the composition, pavement structure is categorized as either flexible or rigid or composite. A typical flexible pavement is composed of layers as in the figure below.

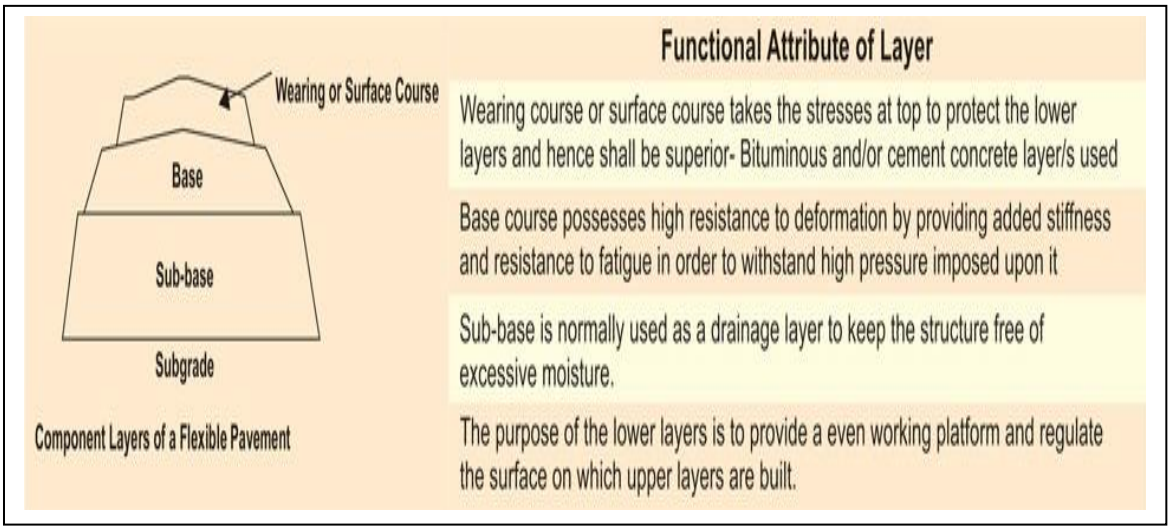

Fig 4 Component Layers of Flexible Pavement

Need for Advanced High-Performance Materials and Technologies

With natural materials getting depleted, efforts were on to find succor in other methods and materials, but till recently, the development of improved materials was mainly focused at improving specific properties of locally available materials by using additives (admixtures, extenders, modifiers). There had been no strong impetus to seriously consider replacing conventional construction materials with new materials. However, by realizing that the age of natural construction materials and the use of conventional materials in their present form is coming to an end at a faster pace. The new technologies need to be developed fast to continue to support the construction activities including rehabilitation and reconstruction of pavements along the road network. Thus, concerns about limited availability and sustainability are driving the search for new and advanced materials for roadway construction.

The currently used materials for pavement construction can be classified as follows:

1.Natural (Raw) Materials: Stone or brick aggregates, bitumen and natural resins.

2. Manufactured (Processed) Materials. Metallic materials (steel, aluminum, zinc), ceramic-based materials (Portland cement, natural pozzolans), industrial by-product materials (fly ash, slag, silica fume), other waste products (crumb rubber), polymers, fibers and fiber-reinforced polymers, synthetic aggregates—typically, lightweight and slag aggregates.

3. Composite Manufactured Materials like. PCC and clad steels.

Further, there is an array of identified materials under the above classes of materials that show potential applications and these advanced materials identified include the following:

1.Aggregate Materials: Synthetic Aggregates, Manufactured Aggregate Using Captured CO2
2.Bituminous Binder Materials: Sulphur-Extended Bitumen/Asphalt, Bio-Derived Bituminous/Asphalt Binders, High Modified Asphalt Binders (HIMA)
3.Bituminous Mixes: Warm Asphalt Mixtures, Perpetual Asphalt Pavement Systems, Porous Asphalt Pavement, Recycled Asphalt Pavements (RAP).
4.Cementitious Materials: Performance-Specified Cements, Next-Generation Sustainable Cements, Eco-Friendly Cements, Energetically Modified Cement.
5.Concrete Materials: Engineered Cement Composites (ECCs), Titanium Dioxide–Modified Concrete, Pervious Concrete, Self-Consolidating Concrete, Sulphur Concrete, Autoclaved Aerated Concrete, Geopolymer Concrete, Hydrophobic Concrete, Ductile Concrete.
6.Metallic and Polymer Materials: Vitreous Ceramic Coatings for Reinforcing Steel, Fibre-Reinforced Polymer Bars for CRCPs and Dowel Bars, Zinc-Clad Dowel Bars, Micro composite Steel for Dowels/Tie Bars.

Emerging Technology Specifications for Flexible Pavements

Presently, there is a necessity of extending our road network to all terrains and environment and flexible pavement being preferred pavement type, there is an immediate need of switching over to high performance/new/alternate materials and technologies that are applicable to flexible pavements and can provide sustainable solutions. To exemplify, bitumen bound layers are normally used in wearing, surfacing, base and binder courses. They may be thick or thin, hot or cold, plant-mixed or site-mixed and so on, but the binding constituent, bitumen has many variants at this time and may include neat or straight run bitumen, cutback bitumen, fluxed bitumen, bitumen emulsion, to name. Likewise, there are other options with different materials to be used in different layers of flexible pavements. The promising new technologies are:

- High performance materials (modified bitumen & multi-grade bitumen)
- Stone matrix asphalt (SMA)
- Warm mix technology
- Cold bituminous mix and half-warm mix technologies
- Waste plastic in road construction
- Self-repairing roads
- Micro surfacing
- Recycling (RAP in bituminous and granular layers)
- Sulphur extended bituminous base courses
- Geo-cells and geo-textiles in pavement construction
- New generation additives for soil stabilisation
- Waste materials including industrial slags and fly ash

Some of these are discussed further.

Modified Bitumen

Though modified bitumen is not a very new concept, the regular usage has been into practice in recent times only. Certain additives or blend of additives called as bitumen modifiers can improve properties of bitumen and bituminous mixes. Bitumen treated with these modifiers is known as modified bitumen. Modifier can be of the following categories:

- Elastomers
  - Natural Latex Rubber
  - Synthetic Latex
  - Styrene-butadiene (SB)
  - Block Copolymer
  - Styrene-butadiene-styrene (SBS)
  - Reclaimed Rubber
- Plastomers
  - Polyethylene
  - Polypropylene
  - Ethyl-vinyl-acetate (EVA)
  - Polyvinyl chloride (PVC)
- Combinations

Polymer modified bitumen (PMB)/ crumb rubber modified bitumen (CRMB) should be used according to the specification requirements of the job. The detailed specifications for modified bitumen have been issued through IRC: SP: 53. It must be noted that the performance of PMB and CRMB is dependent on strict quality control, especially on temperature during construction. The advantages of using modified bitumen are as follows:

- Lower susceptibility to daily and seasonal temperature variations
- Higher resistance to deformation at high pavement temperature
- Better age resistance properties
- Higher fatigue life for mixes
- Better adhesion between aggregates and binder
- Prevention of cracking and reflective cracking

Stone Matrix Asphalt (SMA)

SMA is a gap graded aggregate bitumen mix that maximize the bitumen content and coarse aggregate fraction. SMA provides a stable stone on stone skeleton that is held together by a rich mixture of bitumen, filler and stabilizing additive. Cellulose fibres prevent draining of excess bitumen and help in forming a matrix to hold the high bitumen in SMA. SMA is high performance mix for heavy traffic roads prone to rutting.

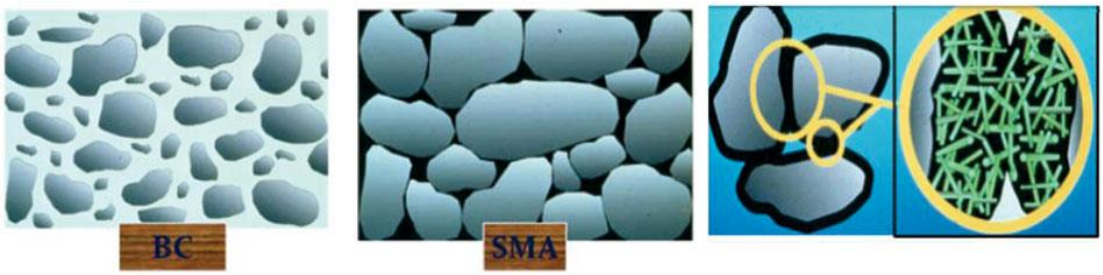

Fig 5 Stone Matrix Asphalt

Warm Mix Asphalt

Warm mix technology is emerging technology, which allows the mixing, lay down, and compaction of bituminous mixes at lower temperatures compared to hot mix. Further, low temperature mixes are classified as Warm Mix Asphalt (WMA) which is produced in the temperature range of 120°C to 135°C and Half Warm Mix Asphalt (HWMA) which is produced in the temperature range of 80°C to 100°C. These technologies have the advantages like:

- Energy saving
- Decreased emissions
- Reduced fuel costs
- Reduced aging of binder
- Lower fumes and odour emissions
- Cool weather paving
- Compaction aid for stiff mix
- Extend paving window
- Generation of carbon credit
- Increase use of RAP

Several processes have been developed to improve mixture workability allowing lower range temperatures for production and lay down. WMA technologies can be classified broadly as (a) those that use water, (b) those that use organic additive or wax (c) those that use chemical additives or surfactants.

Cold Bituminous Mixes

In India, hot mixed bituminous materials and mixes are generally used for the construction of base course, binder course and wearing course of a flexible pavement. The paving bitumen (VG-10, VG-20, VG-30 and VG-40; as per IS:73), is used as a binder. It is either solid or semi solid at ambient temperature and converted into fluid state by either heating or by the addition of petroleum solvent or by emulsifying bitumen in water. High amount of energy is consumed for heating of aggregates and bitumen for construction of roads using traditional hot mix technology.

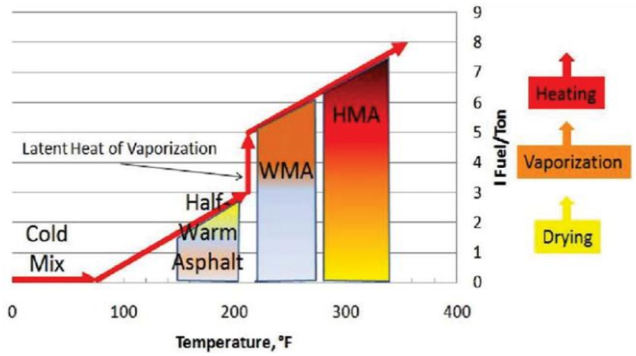

Fig 6 Graph of Latent heat of vaporization.

The following are some of the disadvantages of hot mix technologies:

- High level of noise and air pollution
- Emission of greenhouse gases
- Compromise with the durability of bitumen due to aging during heating
- High energy consumption
- Unsafe for maintenance crew

Lately, Bitumen emulsion has also been used in half warm mixes, micro surfacing and in cold recycling; more especially in full depth reclamation works. Several factors that have led to the increasing use of bitumen emulsion in road construction and maintenance are listed below:

- The energy scarcity and crisis.
- Bitumen emulsions do not require petroleum solvent to make it liquid.
- Bitumen emulsions can generally be used without additional heating.
- Concerns about reducing atmospheric pollution.
- The ability of certain types of bitumen emulsions to coat a damp aggregate surface which eventually reduces the fuel requirements for heating and drying aggregates.
- Availability of a variety of emulsion types which have led to development of new formulations and improved laboratory procedures in order to satisfy the design and construction requirements.
- The ability to use cold bituminous materials at remote sites.
- The applicability of emulsions for use in preventive maintenance so as to increase the service life of existing distressed pavements.
- Health of construction workers

Bitumen emulsion-based mixes include:
(A) Cold Mixes (CM): These mixes are normally produced with unheated aggregates and bitumen emulsion.

Fig 7 Cold Mix Plants

(B) Half Warm Asphalt Mixes (HWAM): These mixes are produced by mixing bitumen emulsion, or foamed bitumen, with warm aggregates (110+10ºC), laid and compacted at a temperature between 80-90ºC.The cold emulsions-based mixes, thus, may be conveniently used in the specified conditions and as per the guidelines given in IRC: SP 100 -2014.

Waste Plastic in Road Construction

Plastic, a toxic material is extensively used in different forms in present day's life and constitutes to almost 5% in municipal solid waste. It is a common sight in India to find empty plastic bags and other type of plastic packing material littering the roads and choking the drains. Due to its impermeability clubbed with non-biodegradability, it creates stagnation of water and associated hygiene problems besides reducing the fertility of the land. In order to reduce the accumulation of waste plastic and also use it for betterment of structures like roads, research carried out has indicated that the waste plastic, when added to hot aggregate will form a fine coat of plastic over the aggregate and when mix is produced with the binder, is found to give higher strength, higher resistance to water and better performance over a period of time. Therefore, it is pertinent to use waste plastic in the construction of road. It has been observed that modification of bituminous mix with shredded waste plastic may marginally increases the cost by about Rs.3000 per ton. However, this marginal increase in the cost is compensated by increase in the volume of the total mix, thereby resulting in less overall bitumen content, better performance and environmental conservation with usage of waste plastic.

Self-Repairing Roads

Since long the need has been felt to develop 'Self Repairing Roads 'through suitable technology inventions. This requires research that clubs the materials science and structural engineering to create self-repairing roads that are cost effective, have greater longevity and are sustainable, though no such success stories have been heard till now. Of late, it is reported that researchers have developed this distinct technology by formulating stabilized road structures. The regular cement concrete roads have been replaced by this unique formulation wherein about 60% of the cement is replaced with fly ash, thus curbing the usual carbon footprint, especially as cement production releases greenhouse gases. It comes with built-in crack healing, as high strength concrete is supplemented with fiber reinforcement with nano-coating that makes it absorb water and keeps the road hydrated. The mechanism, the researcher claims have fibers which have a hydrophilic nano-coating on them. By hydrophilia (means attract water) this water then becomes available for crack healing. Every time a crack appears, there is always this un hydrated cement supplemented by this water the hydration capability, producing further silicates which closes the crack in time.

Micro-surfacing

Micro surfacing is mainly a cold mix technique which uses modified bitumen-based emulsion to produce a mix of relatively small sized stone aggregates along with cement filler to produce and lay a thinner surface coat. The

technique, however, is useful to refresh the surface of an otherwise structurally sound pavement since it cannot provide any additional strength to the structure. It helps to cover very minor undulations and improve skid resistance properties. It is mostly used in urban roads where adding thick layers leads to other problems like need to increase the footpaths and drainage structures. It is, therefore, regarded as a cosmetic bituminous treatment only. The Micro surfacing shall consist of mixture of modified (Polymer or Rubber Latex) bitumen emulsion, well graded mineral aggregate, water, filler and additive (if needed) proportioned, mixed and uniformly spread over a properly prepared surface. There are two types of micro surfacing, by aggregate size and layer thickness there by, as per IRC: SP81-2008.The finally laid micro surfacing shall have a homogeneous mat, adhere firmly to the prepared surface and provide friction resistant surface texture throughout its service life. The mix is to be a quick setting system i.e., it should be able to receive traffic after a short period of time preferably within about one hours of its laying depending upon weather conditions. It is applied on an existing pavement surface which is structurally sound but is showing the signs of functional distress such as loss of riding quality, cracking and polishing. Generally, micro surfacing is laid in single layer, but when the existing surface is highly polished and/ or cracked, it may be applied in two or more layers.

Ingredients	**Percent by weight of aggregate**
Aggregate	100%
Emulsion	13%
Portland Cement	1.5%
Additive	0.5%
Water	14%

Table 1 Ingredients and percentage of aggregate for Roads

The uses and benefits of micro surfacing may be listed as following.

- Preventive and periodic maintenance and renewals on structurally sound pavement
- Surface defects like cracks and polished surface of various types may be treated
- Used for delay of reflection cracking
- Improvement of skid resistance and rejuvenation of hungry surface
- Noise reduction on concrete pavement
- Fastest construction technology

Pavement Recycling

The process involves:

- Cold Milling and
- Cold Recycling (CR)
- In-plant
- In-place (CIPR)
- Full Depth Reclamation (FDR)
- Hot Recycling
- Central Plant Hot Mix Recycling
- Hot In-place Recycling (HIPR)

Bitumen emulsions are most frequently used for Cold Recycling and Full Depth Reclamation (FDR)

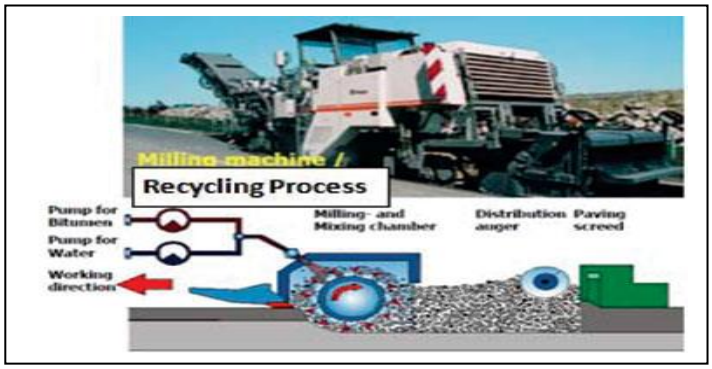

Fig 8 Milling machine

Fly Ash in Pavements

Fly ash is a by-product of burning pulverized coal in a thermal power generating station

- Considering the economic and environmental aspects, industrial by-products like fly ash can be investigated for their suitability as full or partial replacement of materials
- As most of such industrial products are non-plastic, with the use of stabilizing agents, these low-quality materials can be economically upgraded

Fig 9 Fly ash

Geocells

Geocells are believed to provide solutions where the ultimate bearing capacity of foundation soil is not adequate to withstand the applied load, wherein notwithstanding the possibility of shear failure, the anticipated long-term settlement is also high. The simple technology is reported to provide a cost-effective ground improvement system with following features:

- Geocells are normally filled-in with non-plastic granular material, the conventional gravel-sand mix for flexible pavements
- Geocells, used as above improve the bearing capacity of soft strata and construction of the upper layers is possible proceed immediately.
- Geocell laying and filling is fast and an all-weather installation solution. No skilled labour is required. Installation is rapid and local non-plastic material could be used as in-fill.

These features, when successfully achieved, result in substantial savings in money and resources.

Jute Geotextiles

- Jute geotextiles are indigenously made and eco-friendly
- JGT – Different strength characteristics & life span
- Successfully used in geotechnical and highways engineering projects, such as:
  - Road construction
  - Erosion control applications
  - Slope stabilisation and drainage
- Usage is economical

3.2 Advances in Harbors and sea works

Any part of a body of water and the manmade structures surrounding it that sufficiently shelters a vessel from wind, waves, and currents, enabling safe anchorage or the discharge and loading of cargo and passengers. The construction of harbours and sea works offers some of the most unusual problems and challenges in civil engineering. The continuous and immediate presence of the sea provides the engineer with an adversary certain to discover any weakness in the structure built to resist it.

Natural and artificial harbours

In certain favoured points on the world's coastlines, nature has provided harbours waiting only to be used, such as New York Bay, which the explorer Giovanni da Verrazano described as "a very agreeable location" for sheltering a ship. Such inlets, bays, and estuaries may require improvement by dredging and must be supplied with port structures, but basically, they remain as nature made them, and their existence accounts for many of the world's great cities. Because such natural harbours are not always at hand where port facilities are needed, engineers must create artificial harbours. The basic structure involved in the creation of an artificial harbour is a breakwater, sometimes called a jetty, or mole, the function of which is to provide calm water inshore. Locations for artificial harbours are of course chosen with an eye to the existing potential of the coast; an indentation, however slight, is favoured. Yet it has often been found justifiable on economic or strategic grounds to construct a complete harbour on a relatively unsheltered coastline by enclosing an area with breakwaters built from the shore, with openings of minimum width for entry and exit of ships.

Classical harbor works

Improvements to natural harbours and construction of artificial harbours were undertaken in very ancient times. There is no conclusive evidence for the date or locality of the first artificial harbour construction, but it is known that the Phoenicians built harbours at Sidon and Tyre in the 13th century BCE. The engineers of those days either

knew or thought little about conservancy even as applied to the ports they constructed. Evidence is to be seen in the once thriving ports around the shores of the Mediterranean that now are not merely silent ruins but seem so far from even sight of the sea that it is difficult to imagine the presence of seagoing ships at the wharves, the alignment of which can occasionally be traced in the fertile alluvial land now occupying the site. Ephesus, Priene, and Miletus, on the Aegean shores of Asia Minor, are examples of this type of harbour disappearance, the destructive agent in each of these cases being the picturesque Meander (now the Menderes) River, whose creation of new land from the sea is readily perceivable from high ground adjacent to the river mouth. The formation of further bars is proceeding visibly—and, as there is currently no port in the vicinity whose livelihood can be threatened, it is interesting to speculate how far out to sea this process will ultimately continue in the next millennium or so. At Side, facing the island of Cyprus, the remains of an ancient breakwater, built to protect the anchorage, can still be seen, but the area enclosed between it and the advancing shoreline is now not a stone's throw wide. In this case, not only the river in the vicinity but also littoral drift, (the movement of sediments by a current parallel to the coast), which produces and maintains extensive beaches to the east and the west, must be held partly responsible for the scale of siltation. Of many of the ancient port structures, no physical trace remains, but knowledge of the fact that they existed and even a measure of technical description has come down through the written word. With these descriptions and the monuments that remain, some picture may be formed of the work undertaken by the maritime civil engineers of ancient times.

Given the frailty of the craft for which they were providing, shelter from the weather was the prime consideration; and much effort was devoted to the construction of breakwaters, moles, and similar enclosing structures. Cheap labour was abundant, and the principal material used was natural stone. Surviving structures built in this way are likely to give an appearance of indestructibility, which occasionally attracts favourable comparison with the lighter, more rapidly depreciating modern structures. It is not, however, necessary to credit the engineers of antiquity with a conscious intention to build forever. Given the materials they had to use and the purposes they were implementing, they could do little else; moreover, because there was no rapid pace of advance in the development of ships or land transport, they were undisturbed by the shadow of obsolescence. In the 20th century, far from wanting to build forever, the port engineer had to be careful to avoid saddling posterity with structures that might long outlast their usefulness and turn into liabilities. The modern balance between excessive durability and dangerous frailty is one that the ancients never had to strike.

Breakwaters

Because the function of breakwaters is to absorb or throw back as completely as possible the energy content of the maximum sea waves assailing the coast, they must be structures of considerable substance. The skill of the designer of a breakwater lies in achieving the minimum initial capital cost without incurring excessive future commitments for maintenance. Some degree of maintenance is of course unavoidable.

Breakwater design

A common breakwater design is based on an inner mound of small rocks or rubble, to provide the basic stability, with an outer covering of larger boulders, or armoring, to protect it from removal by the sea. The design of this outer armoring has fostered considerable ingenuity. The larger the blocks, the less likely they are to be disturbed, but the greater the cost of placing them in position and of restoring them after displacement by sea action. Probably the least satisfactory type of amour block, frequently used because of its relative ease of construction, is the simple concrete cubic, or rectangular, block. Even the densest concrete seldom weighs more than 60 percent

of its weight in air when fully immersed in seawater; consequently, such blocks may have to be as much as 30 tons (27,000 kilograms) in weight to resist excessive movement. Boulders of suitably dense natural rock are generally much more satisfactory and, in a project completed in the United Kingdom in the 1960s, it was found by experiment, and subsequently confirmed in experience, that armoring of this type could be composed of blocks of as little as six to eight tons to resist the action of waves up to 18 feet (5 meters) in height. The same experiments showed that, to afford the same protection in the same circumstances, concrete blocks of 22 tons would have been necessary. It is usual to construct some form of roadway along the crest of a breakwater, even when this is not required for any other dockside purposes, to facilitate inspection and access for labor, materials, and equipment for damage repairs.

Solid breakwaters

In certain circumstances, particularly in parts of the world where clear water facilitates operations by divers, vertical breakwaters of solid concrete or masonry construction are sometimes employed. Some preparation of the seabed by the depositing and leveling of a rubble mound to receive the structure is necessary, but it is usual to keep the crest of such a mound sufficiently below the surface of the water to ensure its not becoming exposed to destructive action by breaking waves. Repulsion of the waves by vertical reflection rather than their absorption is the philosophy of protection in all such cases, but it is not possible to state categorically which arrangement produces the most economical structure. This type of breakwater can be conveniently constructed through the use of prefabricated concrete caissons, built on shore and floated out, sunk into position on the prepared bed, and filled with either concrete or, less frequently, simple rubble or rock filling. A historical example of this arrangement was the Mulberry Harbor, built by the Allies and floated into position for the invasion of Normandy in 1944. No previous preparation of the seabed was possible, and only partial filling of the caissons had been carried out when the progress of the war rendered further operations unnecessary. Nevertheless, the fact that several of the caissons remained in position basically undamaged for nearly a decade after the invasion on this notoriously stormy coast demonstrated the possibilities of the method.

3.2.6 Floating breakwaters

Because of the large quantities of material required and the consequent high cost of breakwaters of normal construction, the possibility of floating breakwaters has received considerable study. The lee of calm water to be found behind a large ship at anchor in the open sea illustrates the principle. The difficulty is that, to resist being torn away in extremes of weather, the moorings for a floating breakwater must be very massive. They are therefore difficult to install and subject to such constant chafing and movement as to require substantial maintenance. Another problem arises, especially in areas of large tidal range. The unavoidable indeed, essential slack in the moorings may allow the breakwater to ride large waves, so that they pass underneath it is carrying a considerable proportion of their energy into the area to be sheltered. One approach to the problem is based on the concept of causing the waves to expend their energy at the line of defence by breaking on a large, floating horizontal platform.

3.2.7 Docks and quays

Because the principal operation to which harbour works are dedicated is transfer of goods from one transportation form to another (e.g., from ships to trucks), it follows that docks, wharves, and quays are the most important assets of a port. Ships must lie afloat in complete shelter within reach of mechanical devices for discharging their cargoes. Although in emergencies ships have been beached for unloading purposes, modern vessels, particularly the larger ones, can rarely afford contact with the seabed without risking serious structural

strain. The implications of cargo handling, as far as civil engineering works are concerned, do not differ much whether the loading and discharge are effected by shore-based cranes or by the ship's own equipment. In either case, large areas of firm, dry land immediately alongside the ship are required; the engineer must find a way to support this land, plus any superimposed loading it may be required to carry, immediately adjacent to water deep enough to float the largest ship. The capital cost of such works probably increases roughly in proportion to the cube of the deepest draft of ship capable of being accommodated; thus the economic challenge posed by the increase in the size of modern ships is considerable. The advent of containerization the packaging of small units of cargo into a single larger one—has not fundamentally altered this problem, except perhaps to reduce the number of separate individual berths required and to increase greatly the area of land associated with each berth. A figure of 20 acres (8 hectares) per berth is freely mentioned as a reasonable requirement. The problem of land support at the waterline remains the same.

Gravity walls

The solution initially favoured, and indeed predominant for many years, was that of the simple gravity retaining wall, capable of holding land and water apart, so to speak, through a combination of its own mass with the passive resistance of the ground forming the seabed immediately in front of it. To ensure adequate support without detrimental settlement of the wall, to ensure its lateral stability, and to prevent problems of scour, it is necessary to carry the foundations of the wall below the seabed level in some cases a considerable distance below. In earlier constructions, the only guide to this depth in the planning stage was previous knowledge of the ground and the acumen of the engineer in recognizing the characteristics of the ground upon seeing it. Many projects were carried out in open excavation, using temporary cofferdams to keep out the sea. In particularly unfavourable or unstable soils, accidents caused by collapse of the excavation were not unknown. In modern practice, no such project is initiated without exhaustive exploration of the soil conditions by means of borings and laboratory tests on the samples. Continuous monitoring of the soil conditions during construction is also considered essential. Even so, accidents caused by soil instability still occasionally occur. The material composing the walls is today almost universally concrete, plain or reinforced, according to the requirements of the design. This material has entirely superseded the heavy ashlar (natural rock) masonry at one time used for such construction, when the techniques for the large-scale production of concrete were not so well developed as they are today. In some circumstances, particularly those in which the water is reasonably clear or the design and soil conditions do not require very deep excavation into the seabed, the construction of quay walls is adopted by means of large blocks, sometimes of stone but generally of concrete, placed underwater by divers. The economics of this method of construction are influenced by the high cost of skilled divers and by the cumbersome nature of diving equipment. The development of lightweight, self-contained equipment, which leaves the diver considerably more mobile, may relieve this problem.

Concrete monoliths

The risks and difficulties attendant on the construction of gravity walls have been avoided, in suitable conditions, using concrete monoliths sunk to the required foundation depth, either from the existing ground surface or, where the natural surface slopes, from fill added and dredged from the front of the quay wall on completion. This technique amounts to the construction above the ground of quite large sections of the intended wall, usually about 50 feet square in plan, which are then caused to sink by the removal, through vertical shafts, of the underlying soil. Another lift of wall is then constructed on top of the section that has sunk, more soil is removed, and the process is repeated until the bottom has reached a foundation level appropriate to the required stability. Considerable skill is sometimes necessary in the sinking process to prevent the monoliths (usually provided with a tapered-steel cutting edge to the lowest lift) from listing, an eventuality that can occur if any part of the periphery encounters material that is particularly difficult to penetrate. Differential loading of the high side

and special measures to undercut the material composing the obstruction may be necessary. The shafts through which the excavated material is removed are generally flooded throughout the operation simply from the intrusion of the groundwater; if necessary, this water can be expelled by the use of compressed air. The excavation of difficult material in detail and in the dry can then be undertaken. It is an operation of some delicacy, because the flotation effect of the compressed air adds a further element of instability to the monolith, and a blow (sudden leakage of air) under the cutting edge may result in flooding of the working chamber. When the bottom edge of the monolith has reached the designed level, the excavation shafts are sealed by concrete plugs. The shafts themselves can then be filled, either with concrete or with dry filling to give the final wall the required mass for stability.

Concrete caisson walls

In situations in which the depth from ground level to the final dredged bottom is not excessive and the material available for retention as reclamation is of good self-supporting qualities, quay walls can be constructed of precast concrete caissons floated into position and sunk onto a prepared bed in the same manner as that described for breakwaters. Care is taken to design caissons able to withstand the thrust of the retained material, which is carefully selected for the areas immediately behind the quay wall. The conditions suitable for this form of construction are generally typical of the Mediterranean, where the slightness of the tidal variation keeps the depth required to a minimum. In all cases of dock wall construction by concrete monolith or caisson, it is the basic structure of the wall that is provided by these means; the final superstructure, above highest tide level, will depend for its detail on the requirements for dockside services, crane tracks, and other elements.

The piled jetty

The high cost, difficulties, and possible dangers of providing dock and quay walls of the kind just described have always encouraged a search for alternative solutions that would eliminate the need for operations on or below the seabed. Of these, the earliest and most obvious is the piled jetty its piles can be driven from floating craft and the deck and superstructure added thereto, working wholly above water. In regions in which there is a large tidal range, it may sometimes be both advantageous and necessary to take the opportunity provided by extremely low tides to make attachments to the piles for bracing and stiffening purposes. With a reasonable programming of the work, this operation can usually be done without particular difficulty, assuming that the seabed is of a composition reasonably amenable to penetration by piles to a sufficient depth to secure the lateral stability of the structure. Hard rock is not suitable, although some of the more friable rocks can be pierced by steel piles. Piles may be of timber, reinforced concrete, or steel. Timber is a popular choice if there is a large natural supply. Lateral stiffness and stability can be achieved by using a sufficiently close spacing of the piles in both directions and adequate rigid bracing between the tops, timber being a material readily amenable to the workmanship required. Its chief drawback is lack of durability, particularly in the area between wind and water, although a timber jetty with reasonable maintenance can often resist normal operational obsolescence. There are examples of construction in which the piles are connected by casting a reinforced-concrete slab around the heads, its soffit (underside) just below lowest water level. By this means, the timber is kept continually submerged, a condition under which its durability is prolonged. On the other hand, in tropical or semitropical waters or waters kept warm by industrial effluents, the use of timber may be inhibited by the presence of marine borers. Timber jetties have a considerable advantage in the comparative ease with which repairs to accident damage or deterioration can be affected. Reinforced-concrete piled piers and jetties, soundly constructed, exhibit great durability. Attachment to the piles for bracing and similar purposes tends, however, to be more complicated than in the case of timber. This is a disadvantage that applies also to subsequent maintenance and repairs.

CHAPTER 4

4.0 DISCUSSIONS

The fact that infrastructure and finance are the lifeblood of any economy needs no reiteration. Inadequate infrastructure is the biggest constraint in growth and development of Indian economy. To attain the predicted growth rates, India needs to develop robust infra-system. India is facing huge funding gap, which needs to be reduced. Issues such as problem in clearances, difficulty in land acquisition, delay in decision-making, pricing model of infrastructure projects; inadequate dispute resolution mechanism, etc. need to be addressed, to make infrastructure a lucrative investment. There is also a need to create a facilitating atmosphere and set up suitable protections to encourage bigger participation by the private organizations in infrastructure projects. An elementary prerequisite for advancement of investment in infrastructure sector is a favorable policy environment, helpful in appealing private and overseas investment, while shielding community welfares and benefits.

In infrastructure financing, the problem is not that of inadequate savings, but rather deficiency of adequate financial intermediation, proficient in channelizing and mobilizing domestic savings into infrastructure sector. In the last few years, the policymakers have taken numerous measures, such as introduction of PPP model in infrastructure sector, facilitating bank financing to infrastructure sector, stimulating bond markets as alternate source of funding and creating novel and advanced channels of funding, to boost infrastructure financing. However, the regulatory and investment guidelines need further restructuring so that there can be larger scope to promote resilient financial system with diverse investors, innovative financial instruments, alongside liquidity and depth to support long-term funding.

India at present has the highest lending rate among the BRICS nation. The ability to meet infrastructure investment target of US$1 trillion critically depends on (a) the state's capability to make the bond market popular as an alternative source to bank credit and (b) their capacity to bring about financial consolidation and decreasing upward pressure on rates of interest.

According to Ministry of Overseas Indian Affairs (2015), there are approximately 28 million Indians living abroad. Hence, there is a huge untapped potential of diaspora finance for infrastructure development in the country. Since the diaspora savings are mostly locked up in low-yielding bank accounts in the host countries, offering an annual interest rate of 4 or 5 per cent, the Government and reputed private companies can resource the wealth from migrants by selling diaspora bonds offering attractive interest rates. These bonds will also arouse emotional appeal to the NRI to make their valuable contribution in the development of their homeland. Diaspora finance would potentially help in lowering the cost of financing for development projects back home.

Banks have for long played a vital role in infrastructure financing. The credit exposure of banks is stretched to optimal level. Their balance sheet size, growth in non-performing assets and absence of motivations to advance to infrastructure sectors hugely restrict further credit expansion. It is advisable that banks should raise additional capital, by injecting Tier II capital and divestment of government stake, to avoid sector concentration. The mergers and consolidation in banking sector can diminish exposure constraints. The banks should finance the construction and the initial operation period of the infrastructure project, with insurance and pension funds providing the refinancing of bank loans over a long period, this would address the issue of asset–liability mismatch faced by banks. The Indian practice of applying CRR or SLR to 'NDTL' is not in corroboration with the global trends. Currently, the developed countries do not impose SLR requirements for prudential purpose. In the developing countries, the liquidity requirement applicable on time deposits is usually lower than on demand deposits. Some developing countries have SLR rate of less than 17 per cent for liabilities having a maturity period of less than one year and zero for liabilities having a maturity of over one year. Keeping in mind the dual aim of maintaining liquidity for premature withdrawals and compliance of the monetary policy, it is desirable that the application of CRR should be confined to cash and cash-like instruments, which include demand deposits and deposits with no minimum lock-in period. The requirement for SLR should be phased out, in view of Basel II norms, which are characterized by stern asset classification, capital adequacy and provisioning standards and

guidelines. The Basel II norms appropriately ensure that the financial intermediary has sufficient liquidity to service its fixed-time liabilities. Another preposition which the banks can try using is use inter-bank operations to manage day-to-day liquidity, treat savings account balances as long-term funds.

According to Niti Ayog (2015), during the 12th Five Year Plan period, there has been drastic fall in the private investments in the infrastructure sector in the country. It is necessary to (1) re-design the 3P models to rationalize the distribution of risk and reward among the different stakeholders, (2) put in place adequate and effective dispute resolution mechanism, (3) open railways, ports, renewable energy sectors for 3P,(4) design a broad National PPP policy explaining the aims, scope and executing principles of the PPP program envisioned by the state, (5) develop e-due diligence system, to ensure faster clearances, (6) greater transparency in screening process, (7) speedy update of changes made in policy and accessibility to vital data and publications, (8) new 'go-to-market' channels and (9) investment insurance for infrastructure investment projects, in order to restore private interest in the infrastructure sector. Government needs to offer incentives such as reductions and exemptions in taxes (exemption of tax levied on capital good required in the infrastructure sector, fractional VAT reductions when project gets completed, etc.); capped public guarantees (minimum revenue guarantee, guarantee for buyout, etc.); rewards and bonuses (for timely/prompt completion, for avoiding cost over-runs) and compensation for losses arising due to exchange rate movements. It is necessary that incentives or subsidies should be made conditional on social inclusiveness. A set of principal quantifiable impact pointers/indicators should be developed. State also needs to look into diverse models of PPPs such as Design and Build, Finance Only, Operation & Maintenance Contract, Build-Finance, Design-Build-Finance-Maintain, Design-Build-Finance-Maintain-Operate, Build-Own-Operate, Transfer-Operate-Transfer and Build-Lease-Transfer, etc., used across the world, to accelerate infrastructure development in the country.

In several nations, sub-sovereign bonds or municipal bonds constitute a major portion of infrastructure finance. Whereas in India, the municipal bond market is still untapped. It is essential that local governments should act as major drivers in infrastructure development of the country. There is a need to empower the local governments by granting them greater economic autonomy to raise funds for investment in infrastructure projects, with specified ceilings and subject to control measures, making them directly accountable for borrowing and repayment. Local governments use Local Government Financing Vehicles (LGFVs) to circumvent budgetary constraints and leverage their capital base. They can issue 'revenue bond' (in this interest is paid out of anticipated cash inflows), 'common bonds' (they help in funding non-income-generating capital outlays), 'direct pay bonds' (taxable bonds for which interest expense is directly subsidized by the federal government) to finance infrastructure projects. SEBI has set up a framework for issuing and registering of debt instruments by local municipal bodies, but there is a need for fine-tuning those regulations. Combined efforts are obligatory on part of Central Government, State Government and the Municipal Bodies for developing a more reliable municipal bonds market. Measures required to strengthen the municipal bond market in India include (a) revamping of regulatory framework, (b) flexibility in determining interest rate by relating it to a standard market rate, (c) provision for tax-exempt municipal bonds, (d) insulation from interventions, (e) need for credit rating, (f) need for partial or full assurance by Central/State government, (g) requisite for complete disclosure, (h) inbuilt mechanism to hedge risk for the investors and (i) expand the investor base by allowing NBFCs, Pension and Provident Funds and Foreign Portfolio Investors to invest in the securities of Urban Local Bodies and Municipal Bodies.

The depository profile of Insurance Companies, Pension and Provident Funds and Post Offices are more in harmony with the currency requisite of infrastructure. Due to the basic nature of their liabilities, they have the ability to invest for long terms and do not confront the issue of asset–liability mismatch. However, presently these institutions have subdued participation in infrastructure financing. There is a need to suitably modify their exposure limits to the infrastructure sector by approving investment in (a) AA-rated instruments (so-called 'not permitted' investments) and (b) infrastructure projects having assurance from state. India has the fastest rising middle class; however, only a small percentage of its population is investing in insurance and pension products. There is a need to announce proper schemes and appropriate incentives in insurance and pension domain, to generate additional long-term funds for infrastructure investments. Privatization of the pension system can be a

significant stimulus to the development of the fixed-income securities market. Government needs to announce and promote privatized pension system in the country where contributions to pension funds are made automatically out of the monthly salary and another portion the workers are given stock/bonds in proportion to their contribution to the public system. At the time of retirement, the workers are only allowed partial withdrawal, with a substantial portion of their account to be converted into an annuity indexed to inflation. The annuity requirement would lead to substantial growth in country's retirement program and eventually give way to new fund provisions for infrastructure sector. The savings deposited in the various schemes offered by Post Offices also need to be diverted into the investment in the infrastructure projects.

There is a need for well-developed corporate bond market to provide additional funding to infrastructure companies. It is necessary to design framework to enable lenders convert debt into equity in defaulting companies; reform pay and performance structures; devise innovative rating procedures that reward long-term investment in infrastructure sector; encourage innovative financial instruments; relax new foreign portfolio investors rules by eliminating paperwork for entities regulated by foreign securities market regulation; reduce withholding tax and provide tax shield in infrastructure bonds, for boosting investment in infrastructure. The investment bankers can act as bridge between the state and the private organizations by providing innovative financing solutions.

They can do underwriting of the new issues offered by private companies, semi-government entities such as municipal bodies for financing infrastructure projects. There is a need to develop derivatives markets, particularly for interest rates and foreign currency. Indian public utility companies with investment-grade ratings and implicit sovereign guarantees should be allowed to issue foreign currency shares, bonds, ADRs, GDRs and hybrid instruments in overseas markets, but the financial risks will have to be judiciously observed and managed.

Participation of private entities in infrastructure financing will largely depend on the nation's capability: to develop well-organized debt market, making regulatory transformation which facilitates diversification and removing the hurdles for overseas investors. ECBs for infrastructure are inadequate due to (a) poor balance sheets of infra-companies and absence of creditability, (b) interest rate caps, (c) restriction on foreign participation and (d) limited hedging possibilities. Another impediment in exploiting foreign funds is the absence of adequately profound forwards market in foreign exchange.

Government should promote intra-regional infrastructure development, i.e., regional integration and improved connectivity through creation of corridors between sub-regions. This would accelerate infrastructure development, attract new investment and stimulate economic development. For this, it is essential to create synergies and to ensure policy coherence. It is important that there is some common parlance and linkage between the micro and macro policies, between investment and sustainable development strategies and between national and international investment policies. Partnerships between home countries of investors and host countries, trans-national corporations and development banks can assist in reducing information gaps and create united investments in infrastructure sector.

Not all PPPs are successful, some turned to be a failure. Ignoring institutional framework while framing PPPs policies being the major reason behind such failures (Chou et al. 2015, 204–11; Dutz et al. 2006; World Bank 2007).This collaboration or partnership is based on each partner's experience in meeting clearly defined public requirements by allocating resources, risks, responsibilities and rewards appropriately. Any PPP contract's risk allocation is more complicated than that of a traditional construction project.

One of the key challenges in implementing PPP projects in India is a lack of capacity in the public sector. Many explicit and implicit liabilities may be imposed on the government because of PPP initiatives. On several occasions government failed to create a conducive operating climate for the private sector to perform at its best. In developing nation like India, the root causes behind failure of PPP model is lack of trust between public and private sector and the public sector's lack of skills in dealing with private sector (Sharma and Bindal 2014, 1270–4). Previously scholars have worked to identify the factors behind failure of PPP projects and reasons were identified for the reluctance of private players to participate.

CHAPTER 5

5.0 CONCLUSIONS

For the infrastructure firms, success revolves around stitching a credible financing plan. Banks and other financial institution alone cannot meet the future funding requirements of the infrastructure sector hence new innovative avenues of raising capital should arise. For the development of public sector infrastructure, PPP model has emerged as an efficient and sustainable strategy. With the collaboration of technology, financial resources, innovative and improved management techniques, PPP model has potential to contribute to the development of economy along with raising the productivity. Government is realizing the importance of PPP in infrastructure sector to accelerate the infrastructure development. Company regulation rules should be amended by Ministry of Corporate Affairs to make mandatory for the big corporations to invest at least some percentage of their earnings for the infrastructural development of the country. Enhanced role of financial market in providing fund for infrastructure projects can be game changer in India. Despite the theoretic ideal match between enormous source of capital and necessity of investment, the investment in infrastructure has been insufficient to bridge the financing gap. The initiatives have mostly been state-driven, but there is a need for market- and investor-driven initiatives. Governments need to reconsider their approach to support infrastructure financing. Financial markets and intermediaries need to innovate to attract larger funds in response to demand (the search for suitable asset class) and supply (the infrastructure gap). Civil engineering is a multidisciplinary field that plays a vital role in infrastructure development. Through their expertise in structural engineering, geotechnical engineering, transportation engineering, and water resources engineering, civil engineers shape the world we live in. They design and construct infrastructure that meets the needs of society while considering sustainability, safety, and economic prosperity. As we look to the future, civil engineering will continue to be at the forefront of innovation, ensuring that our infrastructure is built to withstand the challenges of tomorrow.

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