Construction Of a Bridge In a Developing Country: A Bangladesh Case Study

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ABSTRACT: This paper presents a case study of the construction of the Jamuna Bridge, the 11th longest bridge in the world. The bridge crosses the Jamuna River (the main channel of the Brahmaputra River in Bangladesh) from Bhuapur on the east bank to Sirajganj on the west, linking the eastern and northwestern parts of Bangladesh. In addition to two carriageways with two lanes each for road transport, the bridge also carries a dual-gauge (meter-gauge and broad-gauge) rail track, a 750-mm-diameter natural gas pipeline, and a 230-kV electrical transmission line across the river. Built at a cost of about $950 million, the Jamuna Bridge is one of the most expensive infrastructure facilities in the Third World. This project posed various challenges to the government of Bangladesh and the international agencies involved. Technical, financial, social, and political challenges had to be overcome, yet despite the complexity and inherent difficulty of this megaproject it is considered a success story. The factors that contributed to the successful construction of the Jamuna Bridge in Bangladesh are chronicled in this paper.

The Jamuna Bridge is currently the 11th longest bridge in the world and provides the first fixed crossing across the Jamuna River linking the eastern and northwestern parts of Bangladesh. The bridge is approximately 110 km northwest of Dhaka, the capital city of Bangladesh. Before the bridge was constructed, the only way to cross the Jamuna River was by slow-moving ferryboats. Traffic jams at the ferry terminals often lasted for several days. A journey that used to take 12 to 36 hours from Dhaka to the northwestern trading town of Bogra now takes only 4 hours (JMBA 2002).

The initial feasibility studies of the project started in 1972 and were completed in 1976. These were followed by a tech-

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noeconomic study of methods for carrying a natural gas pipeline over the river, conducted jointly by Rendel Palmer and Tritton (RPT) and PENCOL, of the U.K., and Bangladesh Consultants Ltd. (BCL) in 1984. That same year the government of Bangladesh decided to proceed with the construction, and the Jamuna Multipurpose Bridge Authority (JMBA) was formed the following year. From 1986 to 1989 detailed studies were carried out by a consortium of RPT, BCL, and Netherlands Engineering Consultants (NEDECO). Construction tenders were called in 1992, and the following year saw the finalization of funding arrangements with the International Development Agency (IDA) of the World Bank, the Asian Development Bank (ADB), and the Overseas Economic Cooperation Fund (OECF) of the Government of Japan. The contracts with contractors were signed in April 1994, and construction began in October of that year and was completed in 1998 in approximately 4 years (JMBA 2002).

The Jamuna Bridge project included the construction of

- The main bridge;
- The bridge-end facilities at the east and west banks of the Jamuna River (for example, parking areas, rest areas, toll booth, staff housing, and so on);
- The approach roads connecting the bridge with the existing road network;
- The river training works.

The main bridge is 4.8 km long with 47 main spans of approximately 100 m and 2 end spans of approximately 65 m. Connected to the bridge are east and west approach viaducts, each with 12 spans of 10-m length and transition spans of 8 m. The total width of the bridge deck is 18.5 m. The carriageways are 6.315 m wide, separated by a 0.57-m-wide central barrier; the rail track is located along the north side of the deck. On the main bridge, electrical interconnector pylons are positioned on brackets cantilevered from the north side of the deck. Telecommunication ducts run through the box girder deck, and a gas pipeline is located under the south cantilever end of the box section.

The Jamuna Bridge marked a turning point in Bangladesh's economic and social development, propelling the country's economy by promoting investment, trade, and job creation, particularly in the country's depressed and less-developed northwest region. In 2001, an average of more than 2,200 vehicles crossed the bridge each day. The flow of trade and services is expected to more than triple by 2010 (The World Bank Group 2002).

From the beginning this project posed various challenges to the government of Bangladesh and the international agencies involved. Technical, financial, social, and political challenges had to be overcome. Despite the complexity and inherent difficulty of this megaproject, it is considered a success story. The following sections will outline the challenges that were faced and the factors that led to the successful construction of the Jamuna Bridge.

Construction of the Jamuna Bridge —The Challenges

The challenges as well as various risks encountered during the planning, design, and construction of the Jamuna Bridge can be categorized as follows.

Technical

The Jamuna, one of the world's major rivers, is a shifting braided river consisting of numerous channels whose width and course change significantly with the seasons. At the bridge site, for example, the width of the river could vary from 5 km in the dry season to about 12 km during the rainy season.

Training the river to ensure it would continue to flow under the bridge corridor was one of the most difficult technical challenges of the project and the most costly of its components. To be more specific, the task was to keep the river under the bridge rather than constructing the bridge over the river.

The river training works were undertaken by HAM-VOA Joint Venture from the Netherlands and were substantially completed in October 1997. The bases of the river training works are two guide bunds, one on each side of the river, to lead the river through the bridge corridor. The bunds are constructed of geotextile fascine mattresses overlaying dredged soil slopes and are covered by rocks and overlaid with open asphalt surfacing. Around 1.5 million tons of rock from Bangladesh, India, Bhutan, and Indonesia were used to provide the coverage for the guide bund slopes (JMBA 2002).

To counter the considerable scour effects of the river, the protection works on the guide bunds extend to depths of 15 to 18 meters below datum, where a falling apron was provided. The additional rocks were dumped in the falling apron to cover the slopes in case of scour, which may go down to 30 meters below datum. The large volume of material dredged to form the guide bunds has been used for reclamation works that provide flood-free land for the bridge and facilities and for resettlement sites (JMBA 2002).

Procurement

Materials

Since the project site is in central Bangladesh, about 300 km upriver from the Bay of Bengal, delivery of the necessary construction materials and equipment posed great problems. On-site delivery by road or rail proved very expensive, and hence delivery barges were selected as the suitable mode of transportation. The bridge was constructed with 1,257 individual prestressed concrete segments, each weighing over 140 tons, which were cast on-site, transported to the bridge

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via floating cranes, and positioned with a 210-m-long lifting beam.

Labor

An enormous workforce labored for four years to construct the bridge. Most of the skilled and unskilled labor was procured from the neighboring villages. Priority was given to those people whose lands were affected by the project.

The bridge contractors were as follows:

- Main bridge construction: Hyundai Engineering and Construction, Korea;
- Approach roads construction: Samwhan Corporation, Korea;
- River training works: HAM-Van Oord ACZ Joint Venture, The Netherlands;
- Rehabilitation of east flood embankment: AML-Monico, Bangladesh.

Construction management services were provided by the following consultants:

- Construction supervision: Rendel Palmer and Tritton (U.K.), NEDECO (The Netherlands), Bangladesh Consultants Limited;
- Management consultants: Halcrow, Price Waterhouse (U.K.), Engineering Planning Consultants (Bangladesh), Rahman and Huq Associates (Bangladesh).

For the overall supervision of the project, the Jamuna Multipurpose Bridge Authority (JMBA) was formed, which consisted of a team of Bangladeshi and international experts. The project was a success because it was planned and performed by a good team whose members had the necessary experience in that type of work and were confident of their ability to repeat earlier success.

The project is a fine example of local participation with a team of international experts to execute the project. This participation helped to train the local engineers and transfer necessary knowledge and skills. Equipment Most of the heavy and specialized equipment was imported from Korea. The government of Bangladesh ensured the timely delivery of the equipment by providing special arrangements to the contractor. This included relaxation of import procedures and reduction in taxes and duties (Huq 2002).

Construction Schedule

The rapidly changing river bed during every rainy season, the variable river path, and the sweltering heat created a great challenge for the contractors to finish the project on time. The whole project was divided into four contracts for the different sections of the bridge, as follows:

- Contract 1. Main bridge: (March 1994–November 1997);
- Contract 2. River training: (February 1994–June 1996);
- Contract 3. Approach road at the east side: (March 1994–March 1996);
- Contract 4. Approach road at the west side: (March 1994–March 1996).

The overall planning and scheduling of the project was done with a simple bar chart program monitored by output S-curves. Further control was obtained by charting and forecasting each activity by calendar dating. Progress reports were submitted on a weekly basis to JMBA and were aimed to be sufficiently informative to forestall most questions (Rasheed 1995, unpublished manuscript).

In summary, realistic planning and scheduling of the work by the contractor and careful monitoring by the JMBA helped to finish the project on time and within the estimated cost.

Financial

Finding a cost-effective way to tame the turbulent and capricious river and the funds required to develop the project was a formidable task that many international engineering experts said could never be achieved. All in all, the project proved a monumental challenge that took nearly 30 years to surmount (Huq 2002).

The Jamuna Bridge was a major capital investment for the government of Bangladesh. The total cost of the project was $950 million, which was provided by the following donor agencies:

- World Bank: US$200 million;
- Asian Development Bank (ADB): US$200 million;
- Government of Japan: US$200 million;
- Government of Bangladesh Development Budget: US$350 million.

The loans carry a low rate of interest (World Bank 0.75 percent per annum; ADB and Government of Japan 1 percent per annum) and are repayable over a period of 40 years with a 10-year grace period.

Funding for the significant government contribution to project costs was provided through a surcharge and levy applied from 1986 to 1994 under the Jamuna Multipurpose Bridge (Surcharge and Levy) Ordinance 1985. The surcharge was collected on rail and ferry charges, telephone bills, motor vehicle licenses, and registration documents for land and buildings. The levy was applied to share and stock dividends and interest on bank deposits, post office savings accounts, savings certificates, and bonds (JMBA 2002).

Evaluation of the economic benefits versus costs produced an economic rate of return for the proposed development of around 14.5%. On reevaluation of the economic data halfway through construction of the bridge in March 1997, this rate of return was confirmed and in fact shown to be a little higher (JMBA 2002).

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Social Resettlement and Compensation

The government of Bangladesh had to acquire a large tract of land (around 5,680 acres) for the project, which affected as many as 100,000 people, either directly or indirectly. Resettling and compensating people whose homes or livelihoods were negatively affected by construction of the bridge was one of the project's major challenges. A budget of over $40 million was used to fund the Resettlement Action Plan and the policy for Erosion and Flood Affected Persons.

Implementation of the resettlement action plan initially did not go smoothly, and there were difficulties in identifying all the households impacted by the project. But with the help of some of Bangladesh's leading nongovernmental organizations (NGOs), nearly 15,000 households affected by the acquisition of land for the project or by erosion and flooding in the affected zone of the bridge were moved to new villages and given land and compensation. Many project-affected people were employed by JMBA or received training to learn new skills to improve their livelihoods (JMBA 2002).

Environmental

Since the inception of the project the government of Bangladesh gave special attention to rehabilitate the environment that could be affected by this project. The environmental protection programs were carried out through major NGOs to ensure the program objectives are fully met and sustained and not constrained to give assistance only during the project period (JMBA 2002). A number of activities have been undertaken such as

- Construction-related environmental impacts have been closely monitored.
- Training in pisciculture has been provided.
- Wildlife monitoring and protection programs have been completed.
- Trees have been planted.
- Health education campaigns have been completed.
- Water quality and the effects on wildlife are being monitored.
- Pond fish culture development programs are being implemented.

THE SUCCESS FACTORS

For Bangladesh's 120 million people, the successful completion of the Jamuna Bridge portends an era of socioeconomic transformations linking the more marginalized north with the rest of the country. The project sets an example for managing megascale projects in Third World countries. The following factors contributed to the success of the project:

Political Commitment

The vision of bridging the Jamuna dates back to 1966, when construction of the bridge was first proposed in the East Pakistan assembly. After Bangladesh gained its independence in 1971, successive governments remained committed to the bridge, and some of Bangladesh's most capable civil servants were continuously engaged in this project. Despite five government changes in 27 years, this project kept its first priority on the national agenda, and this was perhaps the major reason for its successful implementation (Huq 2002).

International Financing and Cooperation

The project reflects a high level of cooperation and understanding between the numerous international donor agencies and the government of Bangladesh. This collaboration was instrumental in the project's being completed within the estimated budget and projected schedule. After the successful completion of the Jamuna Bridge, the same agencies have agreed to support the construction of Padma Bridge to connect the southwest part of Bangladesh with the capital city. This indicates that the successful completion of one project attracts the donor agencies to finance other megaprojects, and this could open new doors to prosperity for developing countries.

Technical Skills

The technical skills of the consultants and contractors helped to resolve any problems at the site quickly without wasting much time. The consultants and contractors were very experienced and had carried out similar projects in the past; they were well equipped and supported and wanted the satisfaction of a job well done, and their enthusiasm and professionalism contributed to the success of the project.

Communication

The main formal channel of site communication was by regular weekly meetings, usually between the JMBA executives, consultants, and the contractor's project management team. The system seemed to work. There was a minimum of contentious correspondence outside the meetings, other than contractually necessary formal notifications. Less formal communications included stops to chat and tea breaks with foremen and inspectors on the job. Further discussions took place over dinner in the evenings. Reports were submitted weekly and were aimed to be sufficiently informative to forestall most questions. Delivering any bad news before it could be received from any other source was a key purpose of such reports (World Bank Group 2002).

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The strong and effective communication between all the parties involved in a project helped them to tackle all small and big problems on site without interrupting the work.

Other Factors

Other factors that contributed to the project's success include the minimization of bureaucracy, regular project monitoring, good relationships between the contractors and the workers, good worker compensation, and strong support from the people and the government of Bangladesh.

Benefits Earned

Economic and Social Development

The completion of the Jamuna Bridge has given a new impetus to Bangladesh's economic and social development, propelling the country's economy by prompting investment, trade, and new job openings. The development of new export processing zones and private tourism complexes on both sides of the bridge is helping to create jobs and reversing the rural-urban migration that has placed increasing pressure on urban centers as millions headed toward big cities such as Dhaka and Chittagong in the past (World Bank Group 2002).

Before the bridge was constructed, fruits and vegetables being transported from the northwest region were often damaged or spoiled in transit before reaching markets on the other side of the Jamuna River. By reducing travel time, the bridge has enabled farmers in the northwest region to take advantage of their marketable agricultural surplus and enjoy higher earnings. During the devastating 1998 floods, the bridge played a critical role in preventing famine by enabling food and relief supplies to be transported quickly from one side of the country to the other (World Bank Group 2002).

Environmental Benefits

The bridge has further environmental benefits. It has reduced the width of the Jamuna River at Kalihati from 12 to 4.8 km, a move that has freed millions from the curse of erosion caused by the swirling motion of the waters, which destroyed land and homes along the river. A recent study found that at least 70 percent of the land surrounding Jamuna was permanently saved from erosion by the bridge's channeling effect. Moreover, the electricity and gas interconnectors that are part of the project brought an end to the acute energy shortages in the northwest, where the only source of fuel was firewood (World Bank Group 2002).

Transfer of Technology

The project benefited the local construction industry via transfer of technical skills and the latest technology. The foreign contractors and consultants hired the local subcontractors and engineers and trained them to work on this advanced project. Moreover, when the project was finished, the foreign contractors sold most of their equipment to the local contractors, which helped to advance the technological capabilities of the local construction industry. This can be seen in the large share of local contractors in the construction of the Padma Bridge project (under construction), which is twice the scale of the Jamuna Bridge project.

More Funding for Future Projects

The successful completion of the Jamuna Bridge has increased the level of confidence of the foreign investors and donor agencies, and the last five years have seen a big investment jump by international financial agencies, governments, and private organizations.

Conclusions—Lessons Learned

From the successful completion of the Jamuna Bridge project, the following lessons can be learned:

- In developing countries, the political willingness and commitment of the leadership/government is one of the most important parameters for successful implementation of a megaproject.
- International funding and support could play a major role in the development of infrastructure facilities if a strong communication link is established between the local government and the donor agencies.
- The consultants and contractors should have adequate experience and skills to execute a megaproject. Selection should be very competitive and based on merit.
- Strong communication among project participants significantly helps to keep the project on the right track.
- The local government should ensure participation by the local people of the area and NGOs to avoid any social backlash.

A recipe for success learned from this project is to analyze, keep it simple, communicate well, get on with it, reevaluate, deter bureaucracy, stay focused, innovate, and learn from one's mistakes.

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