Section 7. Terms of Reference (TOR)

Procurement of Consultancy Services for
Physical Hydraulic Model Study of Sukkur Barrage

TERMS OF REFERENCE

1. Introduction

The Government of Sindh has received a credit from International Development Association (IDA) under Sindh Barrages Improvement Project Additional Financing (SBIP AF), approved on May 25, 2018, to ensure safety of Sukkur Barrage, to enhance monitoring capability of three barrages in Sindh for improved barrage operation, and conduct additional technical studies including River Basin and Riverine Area Management. The broad goal is to uplift the agro-based economy at provincial level thereby ensuring growth in national GDP by increased share of agricultural produce from Sindh.

The government of Sindh intends to apply part of proceeds of the credit for carrying out the Physical Hydraulic Modeling Study of Sukkur Barrage, which is covered under SBIP AF.T This study is aimed at obtaining an independent confirmation of right bank river training works proposed by M/s Atkin-ACE-NDC Joint Venture Consultants in their Feasibility Report (2015) for increasing the flood handling capacity of barrage to 1.5 million cusec, and enabling better silt management in right bank canals.

2. Sukkur Barrage

Sukkur Barrage is located about 225 air miles north east of Karachi (68° 50’ 44’’ E, 27° 40’ 48’’ N) in the Sindh Province of Pakistan. The location of the barrage is shown in Figure 1.

Sukkur Barrage was the first barrage constructed on the Indus River. The works for Sukkur Barrage and Canals Project were started in 1923 and the project commissioning was done in 1932. This is the World’s largest single unified irrigation network with total gross command area (GCA) served the by the seven off-taking canals as 8.2 million acres on both banks of the Indus River, in Middle and Lower Sindh. Out of this 7.6 million acres are cultivable. The maximum abstraction by all the canals is 64,728 cusecs at present, compared to the total designed capacity of 47,530 cusecs. The maximum design flood for the barrage was 1.5 million cusecs. However after extensive modifications in 1939-40, with construction of river training works (to control sediment intake by right bank canals) and permanent closure of 10 barrage spans, the flood capacity was reduced to 0.9 million cusecs.

Sukkur Barrage comprises of a 66 spans main barrage, 4,725ft (approx. 1.4 km) long constructed across River Indus at Sukkur in 1932-36. The structure is mainly of stone masonry construction with reinforced concrete arches spanning 60ft openings for the two bridges; an upper deck used for operating the gates and a lower road deck. The canal head regulator structures on both the banks control flow in the three right bank canals of Dadu, Rice and North Western canals and four left bank canals of Khairpur Feeder West, Rohri, Khairpur Feeder East and Nara Canals. The canal regulators are low level structures carrying a deck area for operating the gates and a road bridge.

The river training works upstream of the main barrage comprise of divide walls, a submerged weir and approach/tail channel with outer and middle banks within the river and an inner bank adjacent with the right guide bank. An island was also created between the middle bank and approach channel which permanently closed ten river spans as a result of modification done in 1939-40. Figure 2 shows the layout of the barrage existing training works. This sediment exclusion mechanism relies on generation of secondary currents to exclude coarser sediments and to allow relatively finer sediments into right bank canals.

3. Issues to be addressed

Although the construction of right bank training works was able to control the excessive sediment entry into right bank canals, it severely curtailed the flood handling capacity of the barrage. The reduction in flood capacity was considered acceptable up until early fifties, as flood discharges were below 0.8 million cusec. However after extensive flood protection works and construction of bunds / levees on both banks of River Indus, the spreading of river flows was prevented resulting in marked increase in floods starting with floods of 1.0 million cusec in 1958. Since then, this increasing tendency in combination with hydrological behavior of Indus River has resulted in 11 instances when river flow crossed 0.9 cusecs; of these events six exceeded 1.2 million cusec. Although all of these floods passed through Sukkur Barrage without any major damages, they were found to be extremely strenuous to the barrage structure. Without any measures for increasing the discharging capacity of Sukkur Barrage, the sustainability of agriculture in Sindh Province shall be at stake.

A noticeble consequence of modifications carried out in 1939-40 is the concentration of flood flows in the middle part of the barrage, while the left and right segments are now taking only a small part of flow. Flow concentration beyond design limits is very risky from barrage safety point of view, and has to be avoided for the continued serviceability of this important structure.

Reduced river flows reaching Sukkur Barrage and increasing pond levels have contributed to silting at upstream of barrage, in the left pocket, tail channel and right pocket, causing oblique approach of the main river. The reduced flows passing downstream of the barrage are also resulting in heavy siltation at downstream. With the dis-use of closed gates, the downstream river channel, particularly on the right side has been silted up, degrading the river capacity to carry flood flows, which may pose a serious problem during super floods.
Government of Sindh, being cognizant of this problem, had authorized a number of studies to overcome this limitation of the barrage. These studies include those conducted by Punjab Irrigation Research Institute in 1959-60, by NESPAK in 1982, by NDC in 2005, and more recently in 2015 by a joint venture of M/s Atkins International, ACE and NDC. The first three studies benefited from physical model testing at Nandipur (Punjab) and the last one from similar model testing at Hyderabad (Sind).

All of these studies were carried out locally on distorted sand models which are known to be only qualitative with regard to sediment transport and its distribution into canals. All of these studies relied upon on modifying the right bank training works, and thereby opening up the some or all of the closed spans of the barrage to increase the discharging capacity. However, the impact of proposed modifications on the effectiveness of sediment exclusion mechanism implemented in 1939-40 on the recommendation of Sir Claude Inglis is not so clear. This system may have already become inadequate due to increase in pond level and canal discharges w.r.t. design, as evidenced by rising bed levels of right bank canals requiring periodic dredging to keep theses canals operational.

Before implementation of a particular solution, the Government of Sindh intends to ensure that the chosen solution meets the requirement of flood capacity, does not impair but improves existing sediment exclusion mechanism, improves the flow distribution in various barrage compartments, minimizes oblique flow conditions, vortices and turbulence, and does not give rise to unacceptable scour or shoal formation.. For this purpose, the Government of Sindh now wishes to engage Consultants to carry out independent physical model testing of various solutions and give its recommendation for the best solution which should be implemented on Sukkur Barrage Rehabilitation and Improvement project. Appropriate numerical models shall also be used to support the implementation of physical model (s) and interpretation of results. The Consultant is expected to use best international standards for the assignment which also meet the quality assurance requirement for this large undertaking.

4. Scope of Work

In the foregoing context the Consultants shall carry out the following tasks:

Task 1: Collection and Review of Pertinent Data

The Consultants shall collect and review pertinent data for planning, construction and operation of the model which may be available with the client, and which may include

- Detailed features of the projects
- Geomorphological setting of Sukkur barrage
- Sediment sizes and concentration
- Current flood and sediment management practices
- Most recent survey of the barrage area, as may be available
- Hydrographs of important floods, flood levels, gate openings and canal discharges
- Summary of previous physical model testing studies.

To receive well focused proposals, the client is providing a summary of most of the above mentioned information as available as Annex to TOR (Technical information for Hydraulic Model Study) with RFP. If necessary, the Consultants may also visit Sukkur Barrage to familiarize itself with the project and its issues, obtain any pertinent additional information and for assuring accuracy and quality of information to be used in the study.

Task 2: Identification of Relevant Physical Processes

From the study of collected information the Consultants shall identify relevant or dominant physical process (s) which are to be modeled to address the problems phrased in section 3 above. The omission of lesser processes which are not scaled in the model(s) may be properly justified.

Task 3: Models and their Scaling

The model domain may be approximately between limestone outcrop (3 km upstream of barrage) and 1 to 3 km downstream of barrage, as may be necessary, although river surveys upto 5.6 km downstream of barrage as well as some distance upstream of limestone outcrop are available for constructing multiple models, if a single model is not practicable at a reasonable scale or for other reasons The Consultants may decide on the number and types of model(s) to be used in the study for resolving the problems. If necessary the Consultants may use partial models or geometrically similar models for specific works of the barrage. It may decide on whether the natural sand or low density material will be appropriate to use in the model, and the degree of vertical distortion which may be appropriate for accurate reproduction of the physical process (s). Particular attention may be given to using suitable model for reproduction of secondary currents which are primary means of excluding sediment from right bank canals. The Consultants shall use reasonably large model facility commensurate with the nature and size of this problem, and minimize scaling effects.

The Consultants may employ appropriate and well tested numerical models to screen various options to be tested on physical models, to provide boundary conditions for partial or comprehensive models, or for better interpretation of study results.

Task 4: Planning the Test Series

The Consultants shall plan the test series, using its best judgement to handle similar problems. In addition to its own conceived interventions or modification to enhance the discharging capacity of barrage and to minimize sediment entry into right bank canals, the Consultants shall include options recommended in 2015 Feasibility Study and those in other such studies for the purpose. Due attention shall be given to include calibration runs for the model to inspire confidence in the study.

Task 5: Implementation of Model Testing Program

The Consultants shall mould the model(s), construct the structures and place the river training and regulation works in the model domain. The Consultants shall use state of art facilities and instruments in the study, calibrate instruments and assess the errors from various sources. It will give due attention to data logging and storage and video recording of model tests. It will perform the test series and adapt the procedure and test series as required.

The Consultants shall analyze the data as test series proceeds. It will interpret data, and convert the results to prototype scale and assess scaling effects, it will establish magnitudes of errors from various sources and quote them together with the interpreted results.

While performing critical runs, it will invite the Client and its representatives to witness the tests and to give their feedback to make it a confidence inspiring and mutually satisfying model testing program.

After completion of the planned testing program, the Consultants shall maintain the physical model for at least one month to allow the Client to deliberate on the recommended solution and to require additional testing for the refinement of the solution, if necessary.

5. Consultants Premises/Office

The Consultants shall notify to the Client the premises/office of its physical model testing facility and the focal person for the study.

6. Study Duration

The study duration is 9 months, and expected to start w.e.f. December 2019.

7. Manpower for the Assignment

Manpower for the study comprises key staff and non key staff as detailed in Table 1 below.

Table 1 Manpower Requirement for the Assignment

A. Key Staff

1. Team Leader and Hydraulic Modeling Expert
2. Computational Hydraulic Expert (Numerical Modeler)
3. Hydraulic Design Expert

B. Non Key Staff

1. Engineers
2. Technicians
2. Craftsmen

Qualification of Key Staff

1. Team Leader and Hydraulic Modeling Expert: He shall have a Master's Degree in Civil Engineering with at least 20 years' of experience in hydraulic engineering, sediment transport, and physical modeling for large irrigation and hydraulic structures. Specific experience on sediment control for barrages and canal offtakes shall be given preference.

2. Computational Hydraulic Expert (Numerical Modeler): The Computational Modeling Expert shall have a Master's degree in hydraulic engineering or related discipline with 15 years of

experience in applying multi-dimensional numerical modeling to hydraulic and sediment transport problems of rivers and hydraulic structures.

3. Hydraulic Design Expert: The Hydraulic Design Expert shall have a master's degree in Hydraulic / Irrigation Engineering with at least 15 years' experience in Irrigation planning and design. Specific experience on sediment control for barrages and canal offtakes shall be given preference.

8. Project Deliverables

(a) The Consultants shall submit the inception report within one month of commencement of services describing the detailed work methodology and model testing program, and schedules.

(b) The Consultants shall submit a model construction report (within two months of commencement of services) on substantially completing the activities necessary for commencement of the physical model testing program, such as construction of physical model, readiness of water supply and sediment feeding and recirculation systems along with necessary materials and equipment and instrumentation, availability of software for numerical modeling etc.

(c) The Consultants shall submit two progress reports describing progression of model testing program and numerical modeling along with interim findings as appropriate, as below.

First Progress report within four (4)month of commencement of services.

Second Progress report within six (6)month of commencement of services.

(d) The Consultants shall submit a Draft Final Report, within eight (8) month of commencement of services, covering its work relating to various tasks under Scope of Work. In this report it will discuss the merits and demerits of various tested solutions or interventions, and give its recommendation for the solution to be implemented on Sukkur Barrage Rehabilitation and Improvement Project to achieve the objectives of the study.

(e) The Consultants, on completion of services, shall submit the Final Report after incorporation of comments, including all data recorded, photographed or video recorded.