

CHAPTER – 4

SURVEYS AND INVESTIGATIONS

4.1 General

Before the finalisation of location of dam, various alternatives of locating the dam both upstream and downstream of the existing Gangau weir had been considered in the light of Ken Multi-purpose Project Report prepared by the State Water Resources Department, Govt. of Madhya Pradesh. Out of these alternatives, the option of locating the dam 2.5 km upstream of the existing Gangau weir, near Daudhan village, was finally selected for field investigation.

As the project envisages inter-basin transfer of water through a link canal, it was decided to carry out the required field survey for the alignment of the link canal from Ken river to Betwa river covering a distance of about 230 km traversing through Chhatarpur and Tikamgarh districts of Madhya Pradesh and Jhansi and Hamirpur districts of Uttar Pradesh. In addition to this, it was also decided to carry out the survey work for fixing the dam axis, location survey for the two power houses and the command area survey.

The dam axis survey was taken up during the month of May, 1992 and the canal and cross-drainage survey in October, 1992. Survey of the Power House No. 1 and colony area was taken up during the months of June, 1993. Survey of a tunnel alignment proposed alternately to replace the originally proposed open canal alignment in the initial 9.4 km reach of Ken-Betwa link and the resultant alternative location of Power House No. 2 was also taken up during November, 1993.

The project proposal includes, inter alia, enroute command area of 47000 ha. It was decided to take up the survey of a representative enroute command area of about 100 ha at feasibility stage of the project. However, the detailed command area survey is proposed to be taken up at the time of preparation of DPR of the project.

Besides, geophysical investigations along dam axis and geotechnical investigations of foundation and construction materials were also carried out through Central Soil and Materials Research Station, New Delhi during July, 1992 to February, 1994.

4.2 Topographical surveys

Topographical surveys have been carried out as per the guidelines given in the Working Group Report prepared by Ministry of Irrigation, Government of India 1980. Brief particulars of the surveys carried out for the different components of the project proposals are given below.

4.2.1 River survey

The portion of Ken river between the proposed Daudhan dam axis and the existing Gangau weir has been surveyed. The cross sections of the river at every 200 m were taken with the help of soundings technique for measuring the depth of water in the river at 25 m interval along each cross section line. The aim of this survey is to determine the capacity of the pondage between Daudhan dam site and the existing Gangau weir, which is proposed to be utilised for the pumped storage scheme (Power House No.1).

4.2.2 Reservoir survey

As mentioned earlier, the State Government of Madhya Pradesh formulated Ken Multi-purpose Project which envisaged construction of dam at about 200 m downstream of the existing Gangau weir across river Ken. For this, the survey of reservoir area was carried out by the Survey of India during the period 1965-67 on request from the Irrigation Department, Govt. of Madhya Pradesh. Maps are available to the scale of 1:15,846 showing contours from RL 234.6 m to RL 295.5 m (or 770 ft to 970 ft.) with contour interval of 3.048 m (or 10 ft.). The reservoir area toposheets prepared by the Survey of India are utilised to work out the reservoir capacity of Daudhan reservoir of Ken-Betwa link project and the corresponding submergence area at the maximum water level for the purpose of land acquisition and compensation to the villages coming under submergence.

4.2.3 Head works survey

In Ken Multi-purpose Project Report, Madhya Pradesh Government has proposed various alternative alignments for a dam downstream of the existing Gangau weir. This will naturally result in the submergence of the existing Gangau weir, which, however, is still functioning well. A study of toposheets by the NWDA revealed a possible option of locating the dam 2.5 km upstream of the existing Gangau weir near the village Daudhan. After making careful reconnaissance and preliminary studies, the site was

found to be more suitable, and the location was finalised. Thereafter survey work on the dam axis was taken up. Topographical survey for a strip of 1 km width (500 m upstream and 500 m downstream) of the dam axis was carried out upto an El 300 m on both the banks. This included the cross section of the river at the dam axis by taking levels at 25 m interval and fixing stones at every 50 m interval along the main dam axis. In addition to this, 4 cross sections were taken on both upstream and downstream of the dam axis at every 25 m interval and another 8 cross sections on both upstream and downstream of dam axis at every 50 m interval. Levels were taken upto the elevation of about 300 m on both banks of the Ken river. A base line was fixed on the left bank of the river and levels were recorded upto a chainage of 0.95 km on left side and 1.4 km on the right side of this base line respectively. A detailed contour plan on the scale of 1:2,000 has been prepared for the surveyed site of Daudhan dam.

At Daudhan dam, a side channel spillway has been proposed for passing the flood discharge. Ski jump bucket type energy dissipator has been proposed. The survey of the dam axis as described above also covers areas of spillway, sloping floor and ski jump bucket etc

4.2.4 Survey of colony area

A site for temporary colony is, however, located near the proposed project site along the Gangau - Palkohan road covering an area of 0.24 sqkm. Block survey of this area was carried out and plan is prepared on 1:2,000 scale. It is proposed that the above colony site will be finally converted into operational staff colonies, after the project construction is completed.

4.2.5 Survey of the canal alignment and canal structures

Strip surveys of 400 m width (200 m on either side of centre line of the canal) along the 231.45 km long alignment of Ken-Betwa link from its offtake point near Daudhan dam axis to the terminal point at Barwa Sagar reservoir were carried out. The alignment was first marked on the field with the help of bearings measured from the toposheet studies and after making necessary corrections for the true-meridian and magnetic meridian as indicated in each toposheet and as well as taking into account the actual site conditions for fixing proper alignment wherever necessary. Marking of the alignment was done by fixing stone pillars at 200 m interval. Concrete pillars were also erected at every one km distance of the link canal and also at each turning point. These pillars were painted with red

colour and chainage written with white paint. Double levelling was carried out and the elevations of the link canal alignment at every 25 m interval were found out. The levelling work was started by transferring a G.T.S. bench mark of Survey of India on the Chhatarpur - Panna road where K-B link crosses near the kilometer stone no. 47/4 on this road. The cross sections of the link canal were taken at every 200 m interval by following the single levelling method. About 130.0 km of K-B link canal survey was completed during the first working season i.e. from October, 1992 to June, 1993 and the survey of the remaining length was completed in the following working season i.e. from October, 1993 to March, 1994. The contour plans and longitudinal sections of the alignment have been prepared and used for the purpose of estimating earthwork quantities.

As per the guidelines of the Working Group Report, grid survey was carried out for each cross – drainage site along the link canal route. Contour plans were prepared on the basis of the grid surveys to facilitate the design work of cross drainage structures, besides marking of final link canal alignment.

4.2.6 Survey of the power house, switchyard, surge tank etc.

As the K-B link project envisages generation of power through two different power houses, block contour survey at these power house sites were carried out. Since the power house No. 2 is located at the end of 2.0 km long tunnel, a surge tank has to be constructed at proper place upstream of the power house. Therefore, grid survey of the surge tank site was also done. Contour plan of the two power house locations were prepared with 1 m contour interval. The surveys for the power houses were carried out to cover sufficiently wide areas so as to accommodate the switchyards too.

4.2.7 Survey of the tunnel, penstock etc.

As it is proposed to locate the Power House No. 2 at the exit end of the intake tunnel, topographical surveys of the natural ground over the proposed tunnel alignment and probable surge tank location are carried out. Further, the survey of penstock alignment to the power house No. 1 located at about 135 m downstream of the dam axis, was carried out. In addition to this, a strip survey covering longitudinal section and cross section of the tail race channel (i.e. link canal) from the power house No. 2 was carried out for a length of 1.75 km, which also covers the cross drainage structure site on Pukhraha nalla.

4.2.8 Survey of the command area

The proposed culturable command area enroute of Ken-Betwa link canal is around 47000 ha out of which 39950 ha lies in Madhya Pradesh and 7050 ha in Uttar Pradesh. Considering the large area and the time factor involved in the field survey of the entire command, a sample survey of a typical block of 100 ha command area was carried out. This is seen to be sufficient for the purpose of the present stage of study report of the link proposal. Accordingly, a typical block of command area near the Sukhani Nadi has been chosen for survey of sample command area and the survey work was completed during January/February, 1994. However, detailed survey of the command area will be carried out at the time of preparation of DPR of the project.

4.2.9 Survey of the construction plants site

As per the reconnaissance at the site, it is proposed that the site for the construction plants can be located on the left bank of Ken river near Daudhan village which appears to be suitable for the said purpose. However, no detailed survey has been carried out for this purpose. The same is proposed to be done at DPR stage of the project.

4.3 Other surveys

4.3.1 Archaeological surveys in the reservoir area

The reservoir area lies in Panna tehsil of Panna district and Bijawar tehsil of Chhatarpur district in Madhya Pradesh. The reservoir area will not submerge any important or historical monument, hence no detailed archaeological survey was conducted.

4.3.2 Mineral surveys

It is seen that no significant mineral deposits suitable for commercial exploitation, have been identified. Therefore, no detailed surveys for this purpose were done. However, the Directorate of Geology and Mining, Madhya Pradesh State conducted a reconnaissance survey at the request of KMPP authority and their report has been obtained for the purpose.

4.3.3 Communication surveys

There is an already existing approach road on the left bank of Ken river, which provides access to the existing Gangau weir constructed earlier across the Ken river. The same can be utilised for Ken-Betwa link project also with the required extensions and improvements. K-B link project envisages the construction of a dam at a site near the Daudhan village, which is only 2.5 km upstream of the existing Gangau weir. The dam site is located about 57 km from the Chhatarpur town and about 21 km from the Chhatarpur-Panna road. The nearest railway station is at Satna on Bombay-Howrah route, which is about 110 km from the proposed dam site. While one power house is located near the spillway of the dam, the other is about 2 km from the Silon village.

4.4 Geological surveys

4.4.1 Visits of geologists

Geologists have visited the project site several times and carried out different investigations. These are described below.

4.4.2 Geological investigations

In order to ascertain the feasibility of the project, an area of 45000 sqm was mapped by Geological Survey of India on 1:12,500 scale on the left flank of the proposed Daudhan dam. In addition to it, a couple of reconnaitary traverses in different reaches along the proposed link canal alignment has been carried out. It comprises of very hard, compact and dense quartz-arenite, which appear to be very competent from the foundation grade point of view. Since only a small part of the area has been mapped, no assessment with regard to the foundation condition in the dam site area has been made. The detailed geological mapping of the entire area is proposed to be carried out at the time of preparation of DPR of the project. As per the geological investigations conducted for the proposed Ken project, the reservoir area comprises pink granite rock free from faults etc. and is reported to be fully watertight.

4.5 Foundation investigations of earth dam, concrete dam and canal structure

The work of foundation investigations (geotechnical and geophysical) was arranged to be carried out through Central Soil and Materials Research Station (CSMRS), New Delhi.

A preliminary foundation investigation (geophysical exploration) was carried out at the dam axis which covers structures like earth and concrete dam, spillways etc. The CSMRS team visited the project site two times. The first visit was made during the month of June, 1993, in which a total length of about 715 m along the dam axis was surveyed by Seismic Refraction Method. The geoseismic longitudinal sections of rock profile/hard strata prepared on the basis of this test are given in their report of August, 1993. The remaining length of the dam axis was surveyed by the second team in the month of October, 1993 and similar geoseismic sections are given in their second report of December, 1993.

A total length of 1413 m along the dam axis was surveyed by the seismic refraction method with 25 profile lines each of 55 m and 2 profile line each of 66 m long. It was found that the P-wave velocity of the overburden is ranging from 200 to 740 m/sec and the range of the velocity in the bedrock is from 2000 to 4600 m/sec. The depth to bedrock from the ground surface is ranging from 0.4 m to 8.4 m.

Another team from geotechnical division of CSMRS visited the site in December, 1993 to conduct foundation and borrow area investigation tests. Disturbed and undisturbed soil samples were collected by means of augur and core cutters from a number of locations along the dam axis as well as from the canal alignment and were tested by CSMRS in their laboratory at New Delhi.

The results of the foundation material tests indicate that –

- i. The foundation overburden strata mostly possess semi-pervious characteristics along the dam axis.
- ii. The soil samples collected from foundation pit in general possess predominantly silt, clay and fine sand sizes with low to medium plasticity characteristics. However, a few soil samples possess non-plasticity characteristics also.
- iii. In-situ dry density and moisture content tests show that the foundation soil is likely to undergo differential settlement particularly

- at shallow depths. It is, therefore, suggested that the soil strata at these levels may be densified by appropriate densification methods.
- iv. The foundation materials possess good shear strength characteristics.
 - v. The specific gravity of the material varies from 2.63 to 2.78.
 - vi. The tested soil samples in general possess low to medium compressibility characteristics.

4.6 Construction materials investigation

The work of investigation of construction materials viz. Soils, rocks and sand was also done through Central Soils and Materials Research Station, New Delhi.

Investigation for the availability of the soil, rock, coarse aggregate and fine aggregate etc. were done on the basis of the location map for construction materials prepared by KMPP authority. Brief notes on the construction material survey are as follows.

4.6.1 Soil

As the proposed earth dam involves huge quantity of earthwork, a number of borrow areas have been identified on both upstream and downstream side of the dam axis. A number of soil samples were collected from the pits located in different borrow areas with the help of augur and were tested by CSMRS in their laboratory at New Delhi.

- i. The results of the borrow area material indicate that –
- ii. Most of the soil samples from borrow areas possess low to medium plasticity characteristics except a few, which exhibit high plasticity characteristics.
- iii. The dry density of soil varies from 1.62 gm/cc to 1.95 gm/cc and the moisture content from 11% to 18.3%.
- iv. Specific gravity of the soil sample varies from 2.64 to 2.79.
- v. The borrow area soil possess good shear strength characteristics.
- vi. The soil samples in general possess low to medium compressibility characteristics and are impermeable.
- vii. The soil samples tested for filter material do not satisfy the filter criteria except the piping ratio criteria, hence the option of using these materials as filter material left to the designers.

4.6.2 Sand/fine aggregate

Various sand quarries are located in the vicinity of the link project. Samples from these quarries were collected by the CSMRS team and tested in their laboratory at New Delhi. Good sand is available in Banne River, which has a minimum lead from the project site.

Results of the laboratory tests done by the CSMRS shows that the samples from Banne river shoal and Barne river shoal are found to be suitable for use as fine aggregate in concrete. However, in view of the higher percentage of silt content, the sand has to be washed before using in concrete.

4.6.3 Rock/coarse aggregate

Locations of the quarries for different types of rock have also been identified in the nearby areas. Rock samples from these quarries were collected by CSMRS and tested in their laboratory at New Delhi.

Results of the laboratory tests done by the CSMRS show that the rock samples collected from Daudhan village quarry and Palkohan road quarry are suitable for use as coarse aggregate in concrete for non-wearing surfaces. The rock from downstream of dam axis quarry is unsuitable for use as coarse aggregate in concrete.

4.7 Agro-economic, socio-economic and environmental survey

As the project construction is likely to make significant environmental and economic impacts in the region, it was felt necessary to carry out a detailed study to assess the likely effects on various aspects such as agro-economic, socio-economic and environment. National Council of Applied Economic Research (NCAER), New Delhi was engaged by NWDA to carry out the bench mark survey of the socio and agro-economic conditions prevailing in the region of the link. Various study teams from NCAER had visited the project areas as well as different locations along the link canal route for collecting informations related to the subject. After collecting all the relevant data a report was prepared in two volumes and submitted to NWDA in October 1993.

Brief outcome of their study is presented as below –

4.7.1 Assessment of likely economic impact from Agricultural production

The methodology, adopted by the NCAER in this study, was suggested by Dr. Gadgil and is based on direct benefits and costs. The increase in income from crop farming with the availability of irrigation facilities is considered as the direct benefit of the project. The changes in income of the other activities of the house-holds in the command areas and consequent changes in total employment are taken as the indirect effects due to higher benefits in agriculture. This will generate demand for various goods and services and give an impetus for various non-farm activities. Detailed outcome of the study on this aspect has been presented in the Chapter-9 on Command Area Development.

4.7.2 Assessment of environmental implications

The assessment of environmental impact was made by the NCAER on the following aspects-

- (a) the type and extent of area to be submerged,
- (b) the likely modification of surface runoff,
- (c) the likely modification of ground water regime and
- (d) the submergence of inhabited areas.

Jungles and forest areas consisting of some important species of trees in the submerged areas shall need a comprehensive afforestation plan to be taken by the project construction authority. Surface runoff to the reservoir area will not be adversely affected. The long hill streams will get shortened resulting in enlargement of channels close to reservoir and thereby increase in silting. However, the increase in silting might be compensated due to reduction in erosion as a result of reduction in distance travel. The ground water level of the places in and around the proposed reservoir is likely to go up which would help in growing of vegetables, fodder and other water intensive crops. It will also help in the growth of natural vegetation around the villages. The ground water regime along the canal alignment would generally remain unaffected as the canal is proposed to be wholly lined. However, application of irrigation water to the command area may lead to water logging in the command area, which need proper implementation and management of water distribution system as well as the drainage system.

The people of the submerged area shall need to be rehabilitated in a model village created with all basic amenities like water supply, electricity, sanitation etc. The aspect on resettlement and rehabilitation (R&R), land acquisition and remaining issues relating to socio-economic & environmental impact assessment are proposed to be studied in detail at the DPR stage of the project.

4.8 Scope for further optimization of the link alignment

It has been observed from the field survey of the 231.45 km long K-B link alignment starting from the offtake point at Daudhan reservoir upto its terminal point in Barwa Sagar that the alignment passes through in some reaches where deep cuttings are anticipated. Although it is not completely possible to avoid the cuttings in certain reaches where the basin boundaries are encountered but there is a scope for further realigning the canal between RD's 100.00 km and 151.00 km so that deep cuttings can be minimised. This may result in reduction of the canal length by about 10 to 15 km and may need to extend the command boundary of the enroute command area towards further north. This aspect may be studied in more details at DPR stage of the project.