

# **TARBELA DAM PROJECT**

by

**SHEIKH AHMAD HASSAN**

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1. My first introduction to Tarbela Dam Project was in October, 1966 when in my capacity as Secretary, Irrigation and Power Department of West Pakistan I was required to attend the Review Meeting in New York.

2. Here I may mention that though the Government of West Pakistan had nominated me as their representative for the Review Meeting, my name was conveniently got dropped at the centre, probably because of the serious controversies I have had with Wapda's Consultants on the various projects in the past and in which with the grace of God I invariably succeeded.

3. When the Provincial Government learnt about my name having been dropped they contacted Islamabad and were informed that it was too late to again include my name in the list of delegates as the file had already been sent to President, Field Marshal Muhammad Ayub Khan then in Swat. The Government of West Pakistan ultimately managed to get President's approval in Swat to include my name. I, therefore, attended the review meetings in New York in October, 1966. Mr. A. G. N. Kazi the then Chairman, Wapda headed the delegation.

4. On the very first day of our meeting I tried to collect information regarding the release capacities of various tunnels to check if these would meet the irrigation requirements. I prepared a statement with the help of the Consultants showing the discharging capacities of various tunnels under different reservoirs elevations.

5. On preparation of the statement referred to above, it was discovered from my long experience of operating all the West Pakistan canals, that the release capacity was not adequate to meet the irrigation requirements in the crucial Kharif sowing months of May and June.

6. I, therefore, raised the issue in the review meetings and suggested construction of an additional tunnel. The Consultants who had already finalised their designs were reluctant to accept the suggestion. There was a complete lack of will on their part to give it a serious thought, in spite of the fact that I repeatedly stated that the millions of irrigators will be hard hit, by holding up in the reservoir, per force, the rising river flows in the months of May and June which were desperately needed for the sowing of Kharif Crops. The controversy dragged on and it was not till 1972 that the Government of Pakistan took a decision to construct a 5th tunnel on the left bank.

7. The Government's decision to construct the 5th tunnel is very gratifying but if it had been included by the Consultants in the original project, the cost would have been met with from the Tarbela Dam Fund. It is now being met from our own meagre resources and is estimated to cost over 70 Crores.

8. Moreover, if this tunnel was available earlier, it would have been of immense help during the disaster of 1974 and again during the current year's catastrophe.

9. The first trouble started on 18-8-1974 when the Stainless Steel Liners in outlet control gate passage of T 3-A failed. Immediately thereafter all 4 outlet control gates were closed. It was then discovered that concrete erosion had occurred in varying degree in all 4 chutes downstream of the steel lined sections. The cause of damage to the steel liners was inadequate grouting during their fixation. The hollows at their back caused serious vibrations which resulted in their being ripped off. The anchors fixed to the liner plates were also found to have inadequate welding as was evident even from visual inspection. The erosion on the chutes was caused by the roughness on their surface because these had not been properly cleaned before commissioning of the Tunnels. This leads on to the feeling that

the work on the project was rushed probably to earn bonus and in this rush the final inspection of the various components of the Dam was not done with the thoroughness that the magnitude and the importance of the Project demanded. The steel liner's which had not yet been ripped of but sounded hollow on being struck with a hammer, were subsequently grouted and additional anchors provided. Their behaviour has been entirely satisfactory during the operations of the tunnels during 1975.

10. The special consultants took a decision after the disaster of August, 1974 to dump the reservoir through all the four tunnels but keeping tunnel 3-A and Tunnel 4-A closed because of damage to their steel liners. It was not unknown then, that the asymmetrical running of tunnel 3 and tunnel 4 would create severe conditions in the cisterns. The Irrigation Research Institute Lahore on the basis of experiments carried out in 1965 had reported and I quote :—

“By operating the Basin No. 4, with left gate open and right gate closed, a strong horizontal circulation results which persists from surface to the floor of the Basin. The movement of the bed material into and out of the Basin can be quite destructive”.

It was, therefore, clear that the cisterns would require to be attended to for the possible damages after the reservoir had been emptied.

11. Unfortunately nothing was done to examine the Stilling Basins and it was not till May, 1975 that the damages in the cisterns of tunnel 3 and tunnel 4 were discovered for the first time. But because tunnel 1 and tunnel 2 cannot be operated under high heads without causing severe damages in them and also because tunnel 5 is not yet ready for operation, there was no alternative but to risk continue running tunnel 3 and tunnel 4 with periodical inspection closures.

12. With regard to the programme of repairs of the Stilling Basins the Special Consultants in their New York meetings on 24/25-6-1975 had advised and I quote :—

- (i) “The tunnel 3 and 4 should be closed, progressively, as soon as the reservoir rises to sufficient height so that

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- (i) “The tunnel 3 and 4 should be closed, progressively, as soon as the reservoir rises to sufficient height so that

required irrigation releases could be supplied by the service spillway, instead of keeping tunnel 3 and 4 fully opened until about September 1st''.

- (ii) One tunnel would be closed when the reservoir reaches elevation 1505 and the other would be closed when the reservoir rises sufficiently higher so that the service spillway alone can supply irrigation requirements''.
- (iii) The rule curve for filling should be revised to ensure that the reservoir reaches elevation 1535 about September 1st in order that the service spillway can supply the required irrigation releases from storage above the spillway crest while tunnels 3 and 4 are closed. Such a procedure would provide ample time for repair of the stilling basins 3 and 4 and in addition maximum time for exploratory drilling and grouting from tunnels 3 and 4''.

13. These instructions were not followed. Tunnel-3 and Tunnel-4 were closed on 29-7-75 but tunnel-4 was opened again on 2-8-75 and tunnel-3 on 9-8-75. The service spillway was opened on 7-8-75 when the Reservoir elevation was 1507.65 but closed the next day. The unfortunate reason for closing the service spillway on 8-8-75 was the threat felt to the electric transmission poles situated along the Daldara Outfall channel, which had not been shifted in advance of opening of the service spillway.

After shifting the electric Transmission line, the service spillway was opened again on 13-8-75. The reservoir elevator on that date was 1514.70', having crossed the 1514' level 4 days earlier on 9-8-1975. The discharging capacity of the service spillway at that elevator is 1,25,000 Cusecs. The total river inflow was 1,93,000 cusecs on 12-8-1975 and 2,10,000 cusecs on 13-8-1975.

Inspite of the fact that great risk had for so long been taken of continued use of Tunnels 3 and 4 after the damages to the floors of their stilling basins had been discovered in May 1975, there was evidently a lack of concern for proper regulation. The continued running of Tunnels 3 and 4 with 1,93,000 cusecs upto 15th of August, was responsible for still another major disaster to this project.

14. Late evening on the 15th of August, when the reservoir elevator had reached 1517.50' and the Tunnels 3 and 4 were discharging 98,000 cusecs and 93,000 cusecs respectively, the turbulence increased in the stilling basin of Tunnel 3. Waves and spray started over-topping the walls, gravel and cobbler size fragments were seen being carried with the waves and spray. Tunnel 3 and Tunnel 4 were therefore, closed on 16th morning. On taking soundings a 70' deep pit was discovered under the floor of the stilling basin of Tunnel 3 and the lower segments of the 80' thick divide wall between Tunnel 3 and Tunnel 4 had dropped deep into the pit.

15. As a result of closing tunnel 3 and tunnel 4, the reservoir level elevation rose to 1531 which was the requirement of the prevailing flood discharge to pass over the service spillway. Having attained a level of 1531, it was decided to hold the reservoir at that level. Raising it to full elevation of 1550' was not considered advisable because of complete absence of dumping facilities, should an emergency arise.

16. Tunnel 1 and tunnel 2 were designed for use in the river diversion to start with and ultimately for power. Their intake gates, three numbers of 45' x 13' in each tunnel, were originally designed for regulation at low heads. Subsequently these were to be sealed and the tunnels were to be fed through the hemispherical gates for power generation.

17. In December 1972 the special consultants made recommendation that TARZAGI'S principle of operational approach be adopted. Some of the details of their recommendations are and I quote:—

“The basic principle is that the option to reopen tunnel 1 and tunnel 2 must remain until the reservoir has been held at practically full level for a sufficiently long period to adequately test the safety of the dam and its foundations”.

“If the behaviour of the foundation is not satisfactory, means will be available to lower the reservoir to a safe level as quickly as possible for the purpose of enabling remedial measure to be carried out. This requires that tunnel 1 and tunnel 2 remain available as diversion tunnels until end of December, 1974”.



“We consider that this procedure would be very desirable. However, it will be necessary to study this plan very carefully to insure that it would be possible to forecast the inflow hydrograph accurately enough; and that the operation of the gates in tunnel 1 and tunnel 2 will be practicable mechanically and hydraulically at pool elevations about 1350”.

“We emphasized that the assured operation of the gates in tunnel 1 and 2 is crucial to the entire filling operation. We suggest that special studies be undertaken to ensure that these gates will be operable under all required conditions”.

18. The Pakistani pannel is not yet fully convinced that adequate and thorough modifications were carried out to the designs of the gates and the tunnels for their mechanical and hydraulic requirments and that their intake structures would behave properly. The way almost all of the six gates have malfunctioned during their operations, indicates that whatever modifications were carried out were not adequate. On questioning the Consultants we were told that the modifications to the gates were carried out in the field and not in the workshop. We wanted to have the views of the manufacturers of the gates on the subject but this has not been made available to us so far.

19. Tarbela Dam Project, once the pride and show-piece of Pakistan, was shattered and crippled. It could be compared to a sick man who had a severe heart stroke, had been hit by paralysis, developed ulcers in his stomach and whose kidneys had almost failed.

Many of the damages are indicative of the lapses in design and lapses in construction and supervision. Hardly there is a component of the project which has not suffered damage of some sort. The Board of Special Consultants consisting of very eminent engineers and specialists in their fields, each one of them a world authority in his subject, have been associated with Tarbela Dam Project for the last many years, ever since its start.

20. We must, however, acknowledge the master mind of the special consultants with which they decided to tackle the

### **Sub para of para 18**

The haste for completion of the Project which secured bonus for the contractor, proved very costly for Pakistan. In this haste, the welding of cap screws to hold down the rails on which the gate rollers move, was missed though it was the design requirement. Because of this omission, the cap screws got unscrewed by vibrations and high velocity jets. This resulted in the displacement of rails, loss of some of the rollers, failure of gates and disaster to the Project. I like to repeat, that the final inspections of the various components of the Project were not done with the thoroughness and sanctity that the magnitude and importance of the Project demanded.

repair work after the disaster in 1974. Their proposals were very bold and sound. Also the credit to have executed the most intricate work in the limited space and tight schedule goes to the TJV. It is an achievement they should deservedly be proud of.

21. But it is extremely unfortunate for Pakistan that a new disaster has struck again in the form of destruction of the stilling basin floors. It is tragic for Pakistan that an examination of the stilling basins was not carried out last year after the dumping of the reservoir, in which process tunnel 3 and tunnel 4 were run assymetrically and the consequences of this type of operation had been forewarned in the Irrigation Research Institute experiments conducted in 1965.

22. The Special Consultants in their Draft Report for Repair, which were discussed in the Review meeting at Tarbela on 4-10-74, had recommended for the reservoir operation during 1975 and I quote:—

“However, we strongly recommend against using tunnel 1 and tunnel 2 or either of them under high heads except in extreme urgency”.

“Also such use of tunnel 1 and tunnel 2 might result in destruction of the pier at the service gates, severe damage in the 90 ft. of concrete lining between the gates and downstream steel liner”.

Again the Consultants in their New York meeting of March 24 and 25 stated as under:—

- (i) It was unanimously agreed that the proposal to open tunnel 1 and tunnel 2 as soon as work inside these tunnels is completed should not be adopted, and that these tunnels will be used only for emergency draw down (and later power).
- (ii) If one or more of the outlet gates on Tunnel 3 or Tunnel 4 should malfunction, it might not be possible to meet irrigation demands with the remaining gates. It was recognised that there might be strong political and economic pressures to make irrigation releases.

- (iii) If Tunnel 3 and 4 should malfunction causing deficiencies in irrigation supplies, neither tunnel 1 nor tunnel 2 should be opened to provide irrigation releases.

23. Pakistan is now in a very unfortunate situation with regard to the use of stored supplies. None of the four tunnels is available to us for releasing the stored supplies and the river is flowing through the service spillway. This will continue to do so till such time that repairs to the stilling basins of tunnel 3 and tunnel 4 are completed, expected in April, 1976. The work has been expedited on T-5 and it is expected to be ready by the end of March, 1976, when trial running and testing will start.

24. For the run of the river discharge to flow over the crest of the spillway during winter months, a reservoir elevation of about 1500 is required. The only water we can withdraw from the storage for the current year wheat crop is, therefore, between elevation 1530 to 1500. This amounts to less than  $1\frac{1}{2}$  M. A. F. and in terms of discharge equal to an addition of 10,000 Cusecs to river flows for about  $2\frac{1}{2}$  months only. I may add here that this addition to the river flows of an average year, gives us less quantum of water than the river flows of a good year.

25. Not only a valuable storage of over 8 M. A. F. on which high hopes for wheat production were pinned, is denied to us during the whole Rabi Season, it stands up there as a potential danger for many many months. The chances are that the reservoir will not get fully lowered before the next flood season, This is not a happy position with the development of hundreds of sink holes (337 number upto date) in the impervious blanket. A lot of earnest prayers are needed. This is all what we can do under the present circumstances.

26. Here I like to mention that we have constructed Warsak Dam, Mangla Dam and the World's largest earth and rock fill Tarbela Dam. But it is a matter of great regret that we have been denied fruitful participation in their design and construction. After construction of these three Dams at a cost of over Rs. 1,500 Crores, we do not have the satisfaction of having trained Pakistani Engineers in the design and construction

of future Dams with local talent, guided, of course, by International experts in various fields which is the normal practice in the construction of high Dams.

27. It is a great tragedy that our engineers have not been associated intimately enough with the Design, Construction and Operation of Tarbela Dam to enable them to take over the project on completion and operate it under strict and meaningful vigilance.

28. Therefore, as soon as Government's decision to construct the 5th tunnel was taken, I addressed a letter to Engr. Dr. Mubashir Hasan, the then Finance Minister of Pakistan, strongly advocating the point of view that the work of its design should be entrusted to Pakistani Engineers. In my capacity as President of the Institute of Engineers Pakistan, I offered to the Finance Minister and gave a guarantee in writing on behalf of Engineers of Pakistan that they were capable of undertaking the design work of the new tunnel. My view was that the Foreign Consultants who had been responsible for the initial lapses in the design, did not deserve any patronage by employing them on a work which had been forced on us because of the lapses on their part and has to be financed from Pakistan's own resources at a cost of over Rs. 70 Crores.

29. The Government very kindly agreed to the proposal and entrusted the work to NESPAK who I am glad have given a good account of themselves. This has helped build up confidence among Pakistani Engineers.

30. Here I may mention that when the decision to construct the 5th tunnel was taken by the Government, the next question was whether it should be executed by Pakistani Contractors or by TJV. Wapda reported that if the work is executed by Pakistani Contractors, the tunnel would be ready for operation in 1978 and if done by TJV, who were already mobilized, the tunnel would be ready in 1976. I was keen to have it ready as early as possible. The Government decided to form a consortium of TJV and the National Construction Co. of Pakistan. Our thanks are due to Dr. Mubashir Hasan for the creation of NESPAK and NCC Pakistan. Both of these organizations, we hope will play vital roles in the National Construction programmes.

31. As stated earlier the repairs under way to the stilling basins are expected to be completed by April, 1976, but after these have been repaired there is no guarantee that the damages will not reoccur. Though every effort will be made, after the disastrous experience not to run these tunnels with unequal gate openings, there is no guarantee that in the life of the Dam, one or the other gate of a tunnel will not mal-function. The Special Consultants have already referred in their New York Meeting on 24th and 25th March, 1975 to the possibility of mal-functioning of the gates. They have observed, as stated earlier, and I quote :

“If one or more of the outlet gates of tunnel 3 or 4 should mal-function, it might not be possible to meet irrigation demands with the remaining gates. It was recognised that there might be strong political and economical pressures to make irrigation releases”.

“ If tunnel 3 and 4 should mal-function causing deficiencies in irrigation supplies, neither tunnel 1 nor tunnel 2 should be opened to provide irrigation releases”.

32. It is evident that mal-functioning of the gates cannot be ruled out for all times to come, with the resultant danger of asymmetrical operation of gates. If one gate of a tunnel mal-functions the tunnel may have to be closed. It might not be possible to meet irrigation requirements from the other tunnel. This increases the importance of the 5th tunnel during the life time of the Dam.

33. When I retired from Irrigation Department in 1968, little did I realise that I was destined to continue effectively advocating for the 5th tunnel and ultimately succeed in getting it sanctioned in spite of the advice to the contrary from the mighty Consultants. Much less could I ever dream of having to sit in judgement over their work after the disasterous happenings to the Project in 1974.

34. Here I like to say a few words about the task assigned to the Panel of Pakistani Engineers of which the Government was kind enough to appoint me as Chairman.

Needless to say, the issue being of extremely high national importance, the Panel set out to tackle the task in great earnestness. Let me state frankly that our task was a difficult one.

35. You engineers would naturally be expecting a comprehensive report from the Panel but you should also know the handicaps we have faced. You would appreciate that to analyse the problems of a Project of the size of Tarbela Dam, on the design of which over Rs. 30 Crores have been paid to the Consultants, who hired hundreds of experts in various fields to do the job for many years, would require trained persons in various fields. The Panel was hoping to get some assistance from the various officers who have had some association with the Project and are now serving NESPAK Ltd. and A.C.E. Ltd. The Government of Pakistan, however, did not agree to a meagre sum demanded by the Panel for this purpose, while millions have been paid to the foreign consultants, of all sorts, invited to visit the damages and repair work for advice. The small amount asked for by the Panel would have provided opportunities for education and training of young Pakistani Engineers. But the Government still does not appear to have learnt a lesson. The Panel was also cautioned that their deliberations may not have implications with regard to claims on the Insurance.

36. However, as we studied various aspects of designs and operations, we were struck with surprises. There have been lapses in design and serious lapses in operation of gates. When it is possible to commission the project after all the repairs have been carried out and it is possible for the Panel to get replies to the various questions that arise, it should be possible to explain more fully the causes for the various failures of the Project. In the existing circumstances when one crisis is followed up by another, it is not possible for the Panel even to question the Consultants who are evidently very much occupied with the repair works. The Government's realisation that the consultant's time should not be encroached upon and also the Cabinet decision not to interfere in the work and proposals of the Consultants has a lot of merit. The decision of the Government is and correctly so, that the repair work should be given top most priority and that the Consultants should continue to have full responsibility for the repairs and operation of the Project till such time as its normal functioning is ensured.

37. As soon as the Government decided to appoint a panel of Pakistan Engineers we decided to have model studies carried out to firm up our views on various issues. Before the necessary funds could arrive from the Government of Pakistan, the work of the Model studies was started with the courtesy of NESPAK. Mr. Irshad, Managing Director, NESPAK was good enough to give a loan of Rs. 50,000/- for the same.

38. With the setting up of models in the irrigation research laboratory, the Consultants who had previously preferred to rely more on the experiments conducted abroad such as at Collarado State University, felt interested in the model studies for the proposed repair works. Realising the top most priority required for the repair works, the Panel decided to the use of the models for proposed repairs. It is gratifying to note that these model studies proved to be extremely valuable for the repair works and their speedy execution. The Irrigation Research Institute Lahore was visited by various foreign experts and the Vice President of the World Bank more than once. We have the satisfaction that the Institute was able to serve the urgent needs of Tarbela repairs.

39. I may state that it is through model experiments alone that we can show to the Consultants what went wrong and why. To illustrate my points, I may mention that the correct sequence to operate the three intake gates of tunnel 1 and tunnel 2 as indicated by the model studies carried out in 1965 was "to first close the centre gate, then either the right or the left gate and finally the remaining gate. The centre gate could be closed completely without creating need of air through the vents at any gate chamber. Since it did not matter which gate was closed next let it be assumed that the left gate is closed next and the right gate last".

It is unfortunate that the central gate of tunnel 2 was operated again and again keeping the side gates closed. The Consultants were asked by the Pakistani Panel as to the effect on cavitation :

- (a) If the central gate was open and side gates closed.
- (b) Side gates open and central gate closed.

The Consultants in the review meeting on 3rd October, 1974 stated that "the situation on cavitation was better with the centre gates operating, not side gates".



The model studies, however, have shown the opposite to be true and have confirmed our thinking on the subject.

40. A study of the gates operation of tunnel 1 and tunnel 2 shows that a proper programme of their operation was not adopted. Efforts were made to adjust these too frequently and in this haphazard operation, centre gate of tunnel 2 got stuck up at 25.5 ft. against its full opening of 45'. This is the worst possible situation for this gate, as also established from the Model Studies. But after the centre gate of tunnel 2 got stuck up on 7-8-74 the consultants thought it fit to recommend to the Government on 14-8-74 to let the reservoir elevation rise for the water to flow over the spillway, though the velocities through the stuck up gate worked out to be of the order of over 120' per second and created conditions for serious cavitation. The Ministry innocently approved ponding up on 17-8-74.

41. The following incidents were indicative of what could possibly be happening in tunnel 2 with the type of gate operations adopted :

- (i) On 2-8-1974, stones and concrete aggregate from tunnel 2 was noticed. The velocity at the Intake with reservoir level 1354.9 on that date works out to about 90 ft per second.
- (ii) On 6-8-1974 rock fragment and concrete fragment were seen washed up on spray deflector deck, which continued till 11-8-74. The velocity at Intake with only Centre Gate open, works out to about 92 ft per second on that day.
- (iii) On 9-8-1974 TJV reported considerable amount of solids being washed out.
- (iv) On 10-8-1974 the water through tunnel 2 was reported considerably darker in appearance than the water emerging from tunnel 3 and 4.
- (v) On 15-8-1974 two re-steel bars were noticed in Tunnel 2. Velocity at Inlet Gate on that date works out to about 118 feet per second, with reservoir elevation 1426.5.

In spite of all this history of tunnel 2, it was recommended by the Consultants to the Government to raise the reservoir elevation for the water to flow over the spillway level 1492'. The Government had no option but to accept the advice of the Consultants though Late Khawaja Azimuddin had advised against such an operation.

Having paid no heed to the warnings mentioned above, the disaster triggered by the severe cavitation, struck tunnel 2 on 22-8-1974.

42. On closing down of tunnel 2, it was confirmed that the cavitation damage was so severe that the heavily reinforced piers of the intake structure had almost entirely disintegrated with similar damages extending to the conduits and the portals of the tunnel.

The Special Consultants in their Draft Report for Repairs dated 4th October 1974 have stated and I quote "The causes of damage are unknown and may never be fully explained."

43. In the end it may be added that the Insurers are stated to have rejected the insurance claim on the basis of inadequacies in the design, etc. The reply received from the Insurers is now under study for comments by the Project Consultants TAMS. You would be interested to know that in addition to the sizeable payments to the Consultants for the original project design, etc., you have not only to pay for the design of the repair works which seems to be an endless process but also for the comments by the worthy Consultants on the rejection of insurance so long as the correspondence with the Insurers continues.