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The Khanki head works situated near the Khanki village at a distance of nine miles downstream of the Alexendra (Wazirabad) bridge, is very vital for the prosperity of the province. It feeds lower Chenab Canal which irrigates two and a half million ares each year and brings in an annual gross revenue of two crores of rupees. The construction of the weir was completed in 1891 and started functioning in March 1892. Originally a weir across the Chenab was constructed and it consisted of 8 spans of 500 feet divided by 10 feet piers. On the extreme left a set of 12 undersluices spans of 20 feet and the canal head regulator with 12f spans of 24.5 feet completed the headworks.

The section of the weir was extremely flimsy and a considerable damage occurred due to the severe floods in the very next year of its opening. In 1895 the damaged portion was dismantled and rebuilt but a further subsidence of the crest took place in October & November of that year.

The Khanki weir was the first weir in the Punjab constructed on the alluvial sandy bed of a river. The incidences of failures prompted Col. Clibborn, Principal, Thomason Civil Engineering college, Roorkee to investigate the laws of flow of water through subsoils below hydraulic works. In 1896, Col. Clibborn recommended that Hydraulic Gradients along the path of flow should form the basis of design. It can be said that the history of failures, repairs and remodelling of this weir is the history of evolution in design of weirs on sand foundations.

Between 1897 and 1931, repeated undermining of the impervious floor of the weir and appearance of leaks & springs through sand, were observed at regular intervals. The damages were repaired with the help of grouting at different locations. In addition to this, a line of wells/sheet piles was added for the protection of the upstream floor. But even with these periodical repairs, the process of undermining was not stopped and large cavities continued to form but remained undetected and ungrouted. Serious damage occurred to the downsteam protection of the undersluices and in the right half, block protection was completely carried away and a 27' deep scour hole below the floor level was formed. In the August of this year, Bay 3 and 4 weirs also faced with grave damages. From the site indication, it appeared to have been a clear case of undermining of the subsoil by piping. This was also confirmed by the very little resistance by pressure pipes inserted in the weir and the extensive grouting in every previous year. Because millions of acres of cultivated area was dependent on the safety of this headworks, the need for the reconstruction of the weir is evident.

A comprehensive scheme of reconstruction was prepared by Mr. H.W. Nicholson, Superintending Engineer which was duly sanctioned by the Government and this project is the subject of this paper. This scheme of reconstruction aimed at securing firstly, the safety of the weir and secondly, the exclusion of harmful silt from the canal. Under sluices, weir bays, Bell's bunds and silt tunnels are the important components where partly or wholly, reconstruction was done.

The silt trouble of the canal started with the first opening of the canal and a large amount of money has to be spent on silt clearance. In the Khanki weir, still pond system, which was very successful at Rupar, was adopted. Due to lack of sufficient attention towards the periodic and adequate scouring of the pocket, the approach was silted up and the control of the river was lost. In 1910 - 11, this method was replaced with open flow system according to which certain quantity of water had to be continuously escaped through the pocket to keep the latter reasonably clear of silt while the canal was in flow. The weir crest was raised by 2 feet in bays 5, 6 and 7 and a subsidiary regulator of 6 bays of 24.5 was added to the main head regulator on the left. Still pond system was again adopted in 1916 and a 2 - feet raising of weir crest in remaining bays was done. Despite therse efforts, silt trouble in the canal remained acute in 1920-22 and a further raising of 2 ft. in crest

was done. Generally unduly high discharges, upto 30,000 cusecs, were passed through the undersluices which resulted in undue development of the left channel and in almost complete choking of the right channel. Water flowed in high floods parallel to the weir from the left to the right. In 1932-33 the existing right channel was closed by constructing a bund and a straight cut of 60' wide was excavated. When the river supply rose, it developed into a widthe of 1200 ft. carrying nearly the same discharge as of the left part of the weir. This development of right channel helped in the control of silt in the canal. The left channel at the bifurcation took off on the outside of curve and right channel took off on the inside of the curve where silt charge was maximum. Bay 4 and 8 were depressed and helped to achieve similar conditions of curvature above the approach to the pocket. In additon to the above measures/reconstruction, 12 main regulator bays had been equipped with 6 tunnels with roof at 5 feet above the raised crest in order to exclude more silt from entering the canal. Partial still pond system is the mode of current regulation. These measures effectively reduced the silt entry into the canal and it is anticipated that the silt trouble of the canal will disappear completely.

Six bays 1,2,3,5,6, & 7 have been reconstructed as weir bays with crest level remaining unchanged. The crest block of the glacis down to the first toe wall has been left intact. The rest below this toe wall to the block area has been reconstructed as impervious floor down to the second toe wall. A line of 'Universal' interlocked steel sheet piles has been driven on the upstream side of the crest. Below the downstream pile line, the reconstructed floor is an inverted filter and after that flexible protection of 40 'length is repaired.

On the block area, a series of arrows have been constructed which throw up and deflect the botom high velocity jets to the top and dissipate energy. The toothed floor surface, the stepped compartment and the arrows form an excellent combination for dissipation of energy.

During the course of reconstruction, a number of cavities were found which were grouted by a grouting machine. The biggest cavity was discovered under pier 5' which extended at least 20' on one side of pier & 13' on the other side.

Bays 4 & 8 were depressed in order to get favourable curvature for silt control. A cross line of piles runs under the divide piers linked at the upstream end to the crest pile line and at the downstream end to the downstream pile line. The piles were driven in the old piers and this part of the work was done with great care. It demonstrates that these types of risks can be taken for such works only with proper planning and supervision. The presence of the clay substratum in bay 4 was responsible for a second pile line at downstream of the crest pile line. The bottom of first line of piles was penetrated in the clay substratum and the indication was that there was a leak from below the clay along the piles into the sand layer above. As the pressure in the clay was more than that in the sand and if in future this leak occurs then the floor will lift up. This possibility was removed by the provision of second line of piles.

The entire concrete in bays 4 and 8 was laid in layers and not in one mass. This type of concreting has certain advantages and disadvantages. The biggest disadvantage is the ligting up of floor under uplift pressures because of the separation of differnt layers and not acting as a single mass. This was effectively avoided by careful design of different layers and the provision of vertical stirrups. In addition to mechanical bond, the layers were thoroughly cleared and a cement grout was applied just before concreting. The drawbacks of mass concreting such as vertical joints, indeterminate internal stresses, high costs etc. were avoided.

Baskets were used for the entire concreting of the floors. the concrete was brought from mixers to the platforms by trucks. The direct dumping from trucks involved certain drawbacks such as mixing of foreign matter by truck wheels in the concrete and segregation of mortar from the aggregate and these were overcome by the use of baskets.

Precast concrete units were also used for greater progress and for economy. Liberal use was made of plums in mass concrete of groynes and blocks. A fish ladder in bay 8 and trough bridges were also constructed. The entire steel work was manufactured in the Central Workshop at Amritsar. Portable pumping sets with 8" to 10" pumps were used for entire pumping. A power house on the left bank consisting of one 40 K.W. and two 10 K.W. sets supplied the required

electricity for lighting and pumping purposes. The Universal and Ransome uniform (D) wer te two types of piles used. The Universal type is heavier in section and good for hard soil. The ransome uniform (D) is also good for hard soils but it bends when driven through stone but it is more water tight and cheaper bacause of lighter section. Oxy-Acetylene flame was used for the cutting of piles. All building stone and pitching stone was obtained from the Irrigation quarry at Baghanwala 87 miles from Khaniki. Ballast was obtained from Jummu, sixty miles away. The entire plant and machinery used was old. Proper planning of every step of reconstruction saved a lot of money.