Paper No. 732

PROPOSAL FOR
REMODELING OF KHANKI HEADWORK VS
NEW BARRAGE CONSTRUCTION

MUHAMMAD ASLAM CHOHAN

PROPOSAL FOR REMODELING OF KHANKI HEADWORK VS NEW BARRAGE CONSTRUCTION

By

***Muhammad Aslam Chohan**

1. KHANKI WEIR:

Khanki headwork on river Chenab situated about 9 miles downstream of Wazirabad was built and made operational in the year 1892. This was the first weir in Punjab which had been founded on alluvial bed of the river. Soon after operation, incidences of failures have been occurring frequently and by the year 1932, sudden collapse of some major part was apprehended to take place. In the intervening period large scale investigation and research work were made and theories of sub soil flow beneath the impervious structures came to surface. On the basis of this research, Mr. A.N Khosla wrote CBI Publication # 12 which even today is considered to be a bible for the design of hydraulic structures on alluvial / permeable soils. All the barrages constructed after the year 1932 in the country on alluvial strata and even those built mostly under Indus Basin Plan have been designed based on the theory and criteria enunciated in this publication.

The weir 4384 ft long constructed in the year 1892 with some later additions consisted of:

a) Two canal head regulators at left flank with crest of subsidiary regulator 5 ft lower than the main regulator.

b) The left under sluice of 12 spans of 20 ft opening each.

c) A weir of 8 spans with widths of each ranging from 441ft to 515 ft on which shutters had been provided to head up the water.

d) Bridges on the two regulators and left undersluice with 10 ft wide road way. A rope way cradle over 8 weir spans had been made for to and fro movement of the supervisory and operation / maintenance staff from one end of the river to the other.

e) Gates and gearing mechanism at the two canal head regulators and left under sluice while the weir part had 6 ft high steel shutters with props at their back; to hold them against the pressure of ponded water.

2. KHANKI HEAD WORKS:

Large scale reconstruction work was undertaken in two consecutive low flow winter seasons of the year 1933-34 and 1934-35 under the supervision of Mr. A. N. Khosla who was incharge Executive Engineer at site. The description of reconstruction work is contained in the Pakistan Engineering Congress Paper # 195 published in the year 1936. The new construction done in the years 1933-35 comprised:-

i. The right end shutter weir bay # 8 was demolished and converted into right undersluice having 18 spans of 20 ft width each with crest 12 ft lower than the adjoining shutter bays. Hoisting mechanism with steel gates 18ft high having top RL 733 were installed in each span to head up water in the pond for meeting canal requirement.

ii. The central shutter weir bay # 4 was likewise demolished and reconstructed as a central undersluice with the geometry and gate hoisting mechanism as that of the right undersluice.

iii. The old groynes # 3, 4 & 7 of the shutter bays were reconstructed as wide divide walls to separate the high crested shutter bays from the 12 ft depressed crest of the undersluices (Plate No.C-4).

iv. The old shutters of weir bays 1 to 3 and 5 to 7 were replaced with new ones, 6 ft high with top RL 733 to head up water on their upstream side.

v. A silt excluder with 6 silt ejector tunnels in front of the main canal head regulator and 3 end bays of the left undersluice was constructed to control silt entry into the canal. The roof of the tunnels was kept at crest level of Main head regulator which is 5 ft higher than the crest of the Subsidiary regulator. There has never been any silt problem in the off taking canal since then.

vi. Road bridge 10 ft wide like that of the left undersluice was provided on the two new undersluices. In this way the rope way cradle got bifurcated in two parts of the shutter bays on the left and right side of the central undersluice. The piers of the bridges were constructed sufficiently strong, wide and long to permit widening thereof in future, (photograph at Plate # C-5)

vii. The weir floor of shutter bays 1 to 3 on the left and 5 to 7 on right side of central under sluice was reconstructed except the crest block. The cavities underneath the substrata were filled and grouted. The loose protections were strengthened on both upstream and downstream sides of the impervious floor. The layout of the head works is at Plate # C-1 while the x-sections of the undersluices and weir parts are at Plate # C-2 and # C-3.

The central undersluice constructed in the middle of the headworks complex with a length of 451 plays a pivotal role in river training of the wide belt and also keeping the bela formation sufficient away from the structure. This also exercises control on excessive sediment loaded water to flow towards the canal off takes. This addition is unique in barrage / headworks constructed in the country and it provides a more reliable control on the river approach especially on a barrage of long length.

3. PROPOSAL OF NEW BARRAGE:

i. In the year 1998-99 a reconnaissance survey of all the barrages / headworks in Punjab was conducted. In view of century old structure, without conducting a detailed investigation or critical analysis the report in general terms recommended construction of a new barrage. This proposal was put up before the Advisory Group in the year 2002 which agreed with the outcome of reconnaissance survey report. The emphasis in the meeting was only of the structure being very old and not meeting the present day requirement.

ii. In line with the recommendations of the reconnaissance report, the department appointed consultants in the year 2003 to undertake studies and evolve a design report for the Construction of New Khanki Barrage. The draft feasibility report in 2005 was circulated to the members of the Advisory Group for review and comments. The report stated the existing Khanki weir built in 1892 and rehabilitated / reconstructed in the year 1933-35 has reached a status of obsoleteness in terms of design and operation. It further stated that the structure is of inappropriate strength and as a whole outlived its useful life and prone to fatal damages. Under such a situation the department decided to construct a new barrage, gate controlled and a bridge crossing over it.

4. COMMENTS ON NEW BARRAGE PROPOSAL

The objective of a gate controlled structure and a bridge crossing is no doubt an essential requirement of modern times. However, before demolishing existing setup and

constructing totally a new complex, a detailed critical examination and testing of existing structure and its components is called for to rule out much less expensive remodeling option. Unfortunately it was not in the purview of the study where consultants were advised to give proposal on new barrage.

With the recent economic crisis both global and national, the cost of new barrage which when originally conceived was PKR 10 billion went up to 24 billion. Understanding the potential limitation of Punjab Government and budgetary constraints, the undersigned reviewed the proposal if it could be managed with low budget and without compromising on the objectives set for a new barrage.

Key findings are as follows:

i. A copy of the reconnaissance report made in 1998-99 was procured. This report fortunately has not reported any significant damage to civil work since reconstruction works of the year 1933-35. The visual examination made by them also indicated no adverse aging signs or settlements or cracking anywhere on that account.

ii. Engineering Congress Paper # 195 on the reconstruction/remodeling works made in the year 1933-35 by Mr. A.N Khosla was also reviewed to get insights on the structure. It revealed that all the structure was in sound shape except the weir bays 1 to 3 and 5 to 7, having shutters to head up water which were cumbersome in operation. If these shutters are replaced into a gated form and a bridge constructed over it, the existing complex will embody all the features of modern barrage for reliable / effective operation of the system.

iii. It is also known that the two head regulators, three set of undersluices, silt excluders, operating machinery and guide banks stabilized have a satisfactory record of good performance without showing any sign of weakness in the past over 70 years operation. These structures have adequate design parameters; sound in construction and behaving exceedingly well for the functions attributable to them. The problem is only in the middle two parts of 6 shutter bays whose operation is outdated, cumbersome and hazardous. These bays need scrapping and conversion, into standard weir structure in line with the present time and provided with gate operation capability. The existing-bridge on three undersluices could be upgraded and joined with the bridge to be made over the new portion of the gated weir.

5. REMODELING OPTION:

i. Undersluices:

The three undersiuices with low level crest (12 ft lower than the shutter bays) and the floor have deep sheet pile line cutoff (RL 694), the bulky side walls / groynes separating the under sluices from the shutters zone are also resting on double line of sheet piles with bottom of outer pile still lower at RL 689- (Plate # C-4 and C-10). The crest of the new structure (to be constructed in replacement of the shutters) working as normal barrage bays could be placed about 5 ft above the crest of existing undersluices as per usual practice (i.e. 7 ft lower than the existing shutters crest). In this way substantial additional water way would also become available to increase flood discharging capacity. The outer piles of the side divide walls / groynes in case of central undersluice are also penetrating in the clayey stratum of two feet thickness. These piles extend in a length of 120 ft to 340 ft beyond the structure part of the undersluice as shown on the plan at Plate # C-10. In a given situation therefore the idea of scrapping the shutter bays and constructing a gated weir at these locations is feasible. This change could easily be implemented by erecting coffer dams to enclose the working area in two working

seasons alternatively (Plate # C-6) without disturbing the canal withdrawals or hampering the escape capacity of winter freshet flows. Under this scheme of work, the existing floor and outfit of shutter bays will of course be completely dismantled / scrapped and replaced by new construction of a regular weir-design with gates and gearing mechanism like the one proposed for new barrage construction. With this change water way of the existing Khankiheadworks shall also greatly increase to pass a discharge of about 11 Lac cusecs (as assessed for 100 years frequency intervalas against presently design capacity of 8 lac cusecs.

ii. Gated Weir Bays:

The recommended design of normal weirbays in the proposed new barrage can be replicated in the existing structure by replacement of shutter bays at a distance of 50 to 100 ft away from the end walls of the three undersluices. The distance has been kept to construct completely new abutments adjacent to the existing ones. This will completely rule out the element of migration / disturbance of the substrata beneath the undersluices. This will of course deprive the advantage of utilizing the existing strong massive abutment of the existing undersluices and instead necessitate provision of new abutment walls on either side of the proposed gated structures. In this way wide islands of 100 to 150 ft width shall appear on ground at the wings of three existing undersluices which can serve as a sitting platform for site view by the tourist / visitors.

The side walls of the three under sluices are quite wide and massive in size. They rest on two rows of deep sheet piles, the inner one 16ft lower than the downstream floor of the undersluice and the other 22ft (Plate # C-10). This mitigates any chance of substrata migration from the sides of existing undersluices to the proposed new construction area in the shutter bays portion.

There is an opportunity to make full utilization of existing strong abutments having two rows of deep sheet piles as shown in plate # C10 & C11 through usage of tried and tested baffle and friction blocks to dissipate energy across the weir as against deep cistern. This system of energy dissipation is tried and tested as most of our structures have been successfully run for over years without any problem. It may be noted that with this arrangement the downstream cistern would no longer be required and the floor top will get raised by 8 ft.

iii. Floor Thickness:

Further economies can be achieved by making improvements in design as suggested below:

i. It incorporates 2ft retrogression in the design of the downstream river bed as against 2ft to 2.5ft accretion developed at site. After the construction of Qadirabad Barrage at a small distance of 12 to 15 miles below Khanki, the accretionary trend is likely to go up in future which will reduce the head cross value across the structure further. Therefore the designed thickness of floor can be reviewed.

ii. Maximum thickness of 12 ft in the downstream floor adopted in the year 2005 and increased to 13.5 in the final design (Plate # C-9) is too heavy and not matching with the barrages constructed under Indus Basin Replacement Plan. It will be of interest to state here that the maximum floor thickness at Rasul Barrage with matching substrata is only 10.5 ft catering for a design head across of 36 ft

as against a maximum of 23 ft to be encountered at Khanki weir / Barrage. Perhaps a maximum thickness of 9 ft in the downstream floor of the new weir section will be adequate to adopt here.

6. CONCLUSION AND RECOMMENDATION:

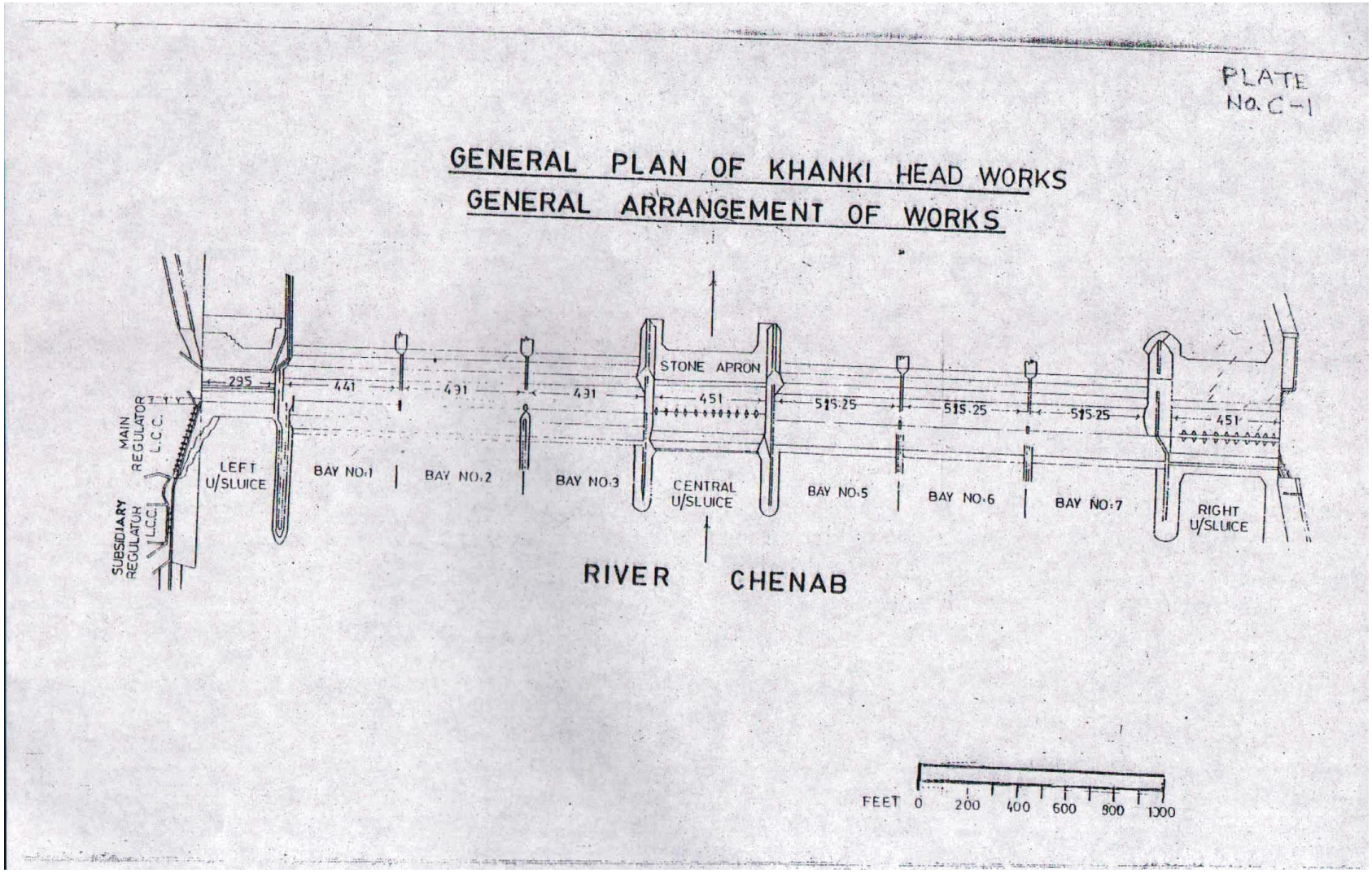
It is amply clear that the choice of remodeling the existing Khanki weirs in the manner suggested is feasible to adopt. It is very simple in construction, less time consuming just two winter seasons working periods) and much cheaper in cost. The suggested scheme or work can be executed with about one third of cost of Rs.10 billion as against estimated cost of Rs. 24 billion for a new barrage construction (Cost estimation in the year 2007-08). River works need timely completion before the flood season and in the absence of commitment of funds for two consecutive years the delays could result in even further increase in the total cost of the project. The proposed low cost solution will allow management to gather funds for a timely execution of the project.

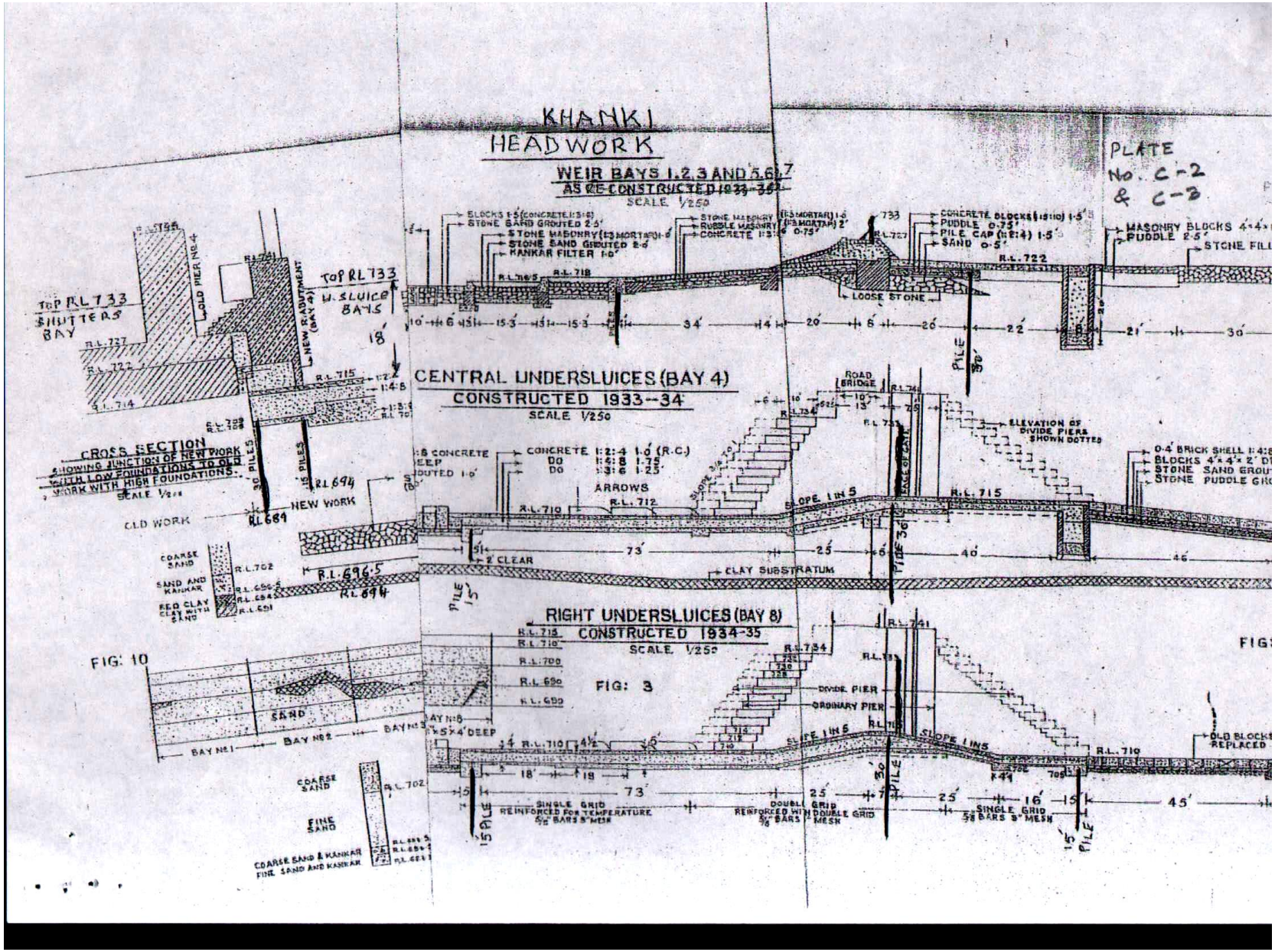
The modified setup of the Khanki Headworks would incorporate all the innovations devised in the new barrage proposal.

7. APPEAL:

The scheme of new barrage construction is misconceived and has been initiated purely on the basis of a sketchy reconnaissance report of the year 1998-99 which too stated that no significant damage to any civil work had taken place ever since construction/remodeling works of the year 1933-35. There is no ageing sign of settlement or cracking anywhere. The existing structure (except the shutter portion) is time tested, massive in size, solid reliable in behavior and problem free. It has hard granite stone facing all along with no scratch or abrasive effect on it.

This is a rare, magnificent old heritage of national pride structure and the same instead of preservation is planned to demolish. This would be an unfortunate self imposed disaster which in state interest needs to be checked. It is humbly submitted that the remodeling proposal as outlined herein be critically examined/ analyzed by knowledgeable technical professionals for a meritable decision to safe guard huge avoidable Government exchequer.


PLATE
No. C-1
GENERAL PLAN OF KHANKI HEAD WORKS
GENERAL ARRANGEMENT OF WORKS
MAIN REGULATOR L.C.C.
SUBSIDIARY REGULATOR L.C.C.
LEFT U/SLUICE
295
441
431
431
STONE APRON
451
515.25
515.25
515.25
451
BAY NO.1
BAY NO.2
BAY NO.3
CENTRAL U/SLUICE
BAY NO.5
BAY NO.6
BAY NO.7
RIGHT U/SLUICE
RIVER CHENAB
FEET 0 200 400 600 800 1000


KHANKI
HEADWORK
WEIR BAYS 1.2.3 AND 5.6.7
AS RE-CONSTRUCTED 1933-36
SCALE 1/250
PLATE
No. C-2
& C-3
CENTRAL UNDERSLUICES (BAY 4)
CONSTRUCTED 1933--34
SCALE 1/250
CROSS SECTION
SHOWING JUNCTION OF NEW WORK
WITH LOW FOUNDATIONS TO OLD
WORK WITH HIGH FOUNDATIONS.
SCALE 1/250
OLD WORK
NEW WORK
ARROWS
CLAY SUBSTRATUM
RIGHT UNDERSLUICES (BAY 8)
CONSTRUCTED 1934-35
SCALE 1/250
FIG: 10
FIG: 3
SAND
BAY No.1
BAY No.2
BAY No.3
COARSE SAND
FINE SAND
COARSE SAND & KANKAR
FINE SAND AND KANKAR
DIVIDE PIER
ORDINARY PIER
SLOPE 1 IN 5
SINGLE GRID REINFORCED FOR TEMPERATURE
DOUBLE GRID REINFORCED WITH DOUBLE GRID
SINGLE GRID

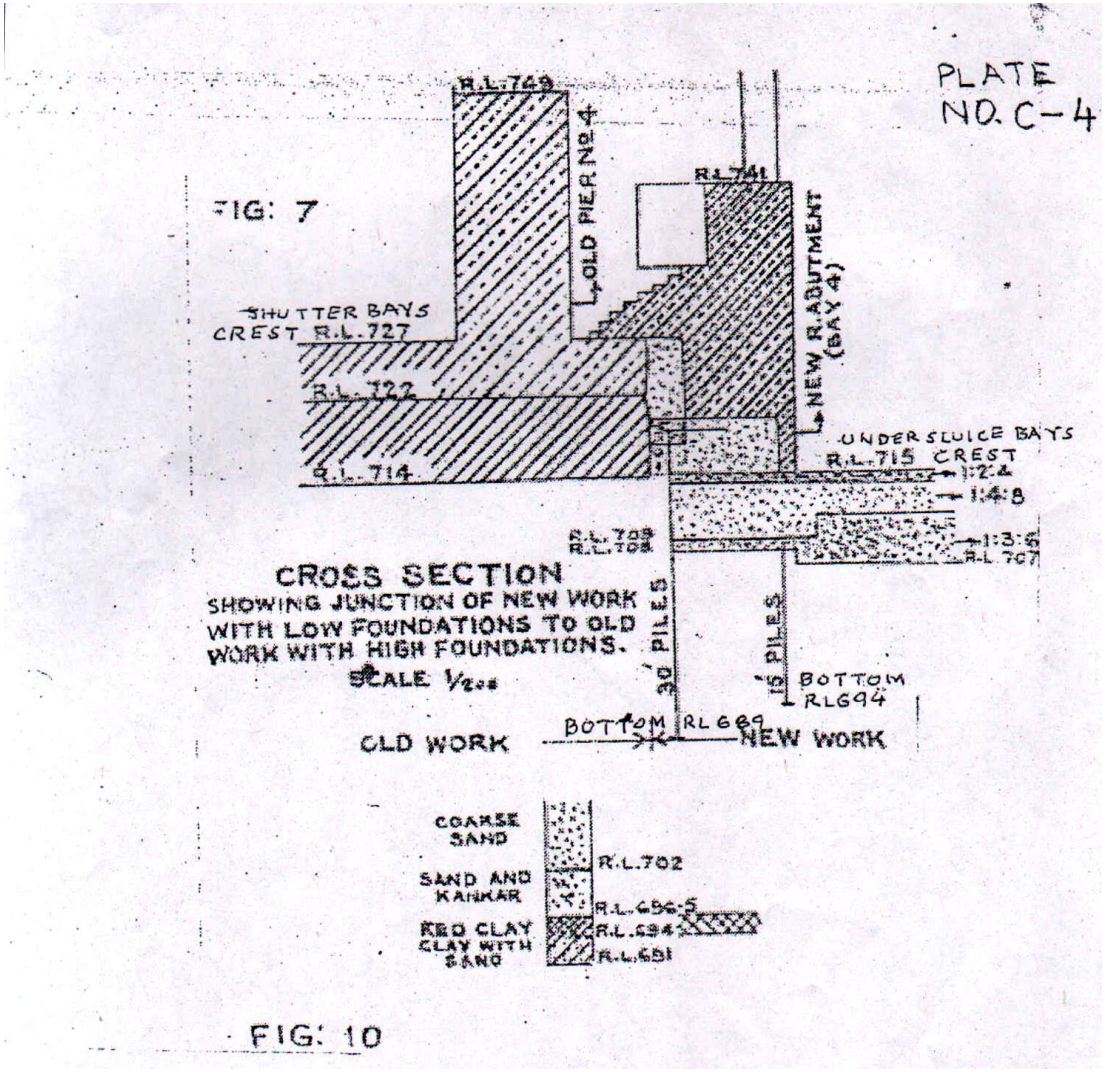
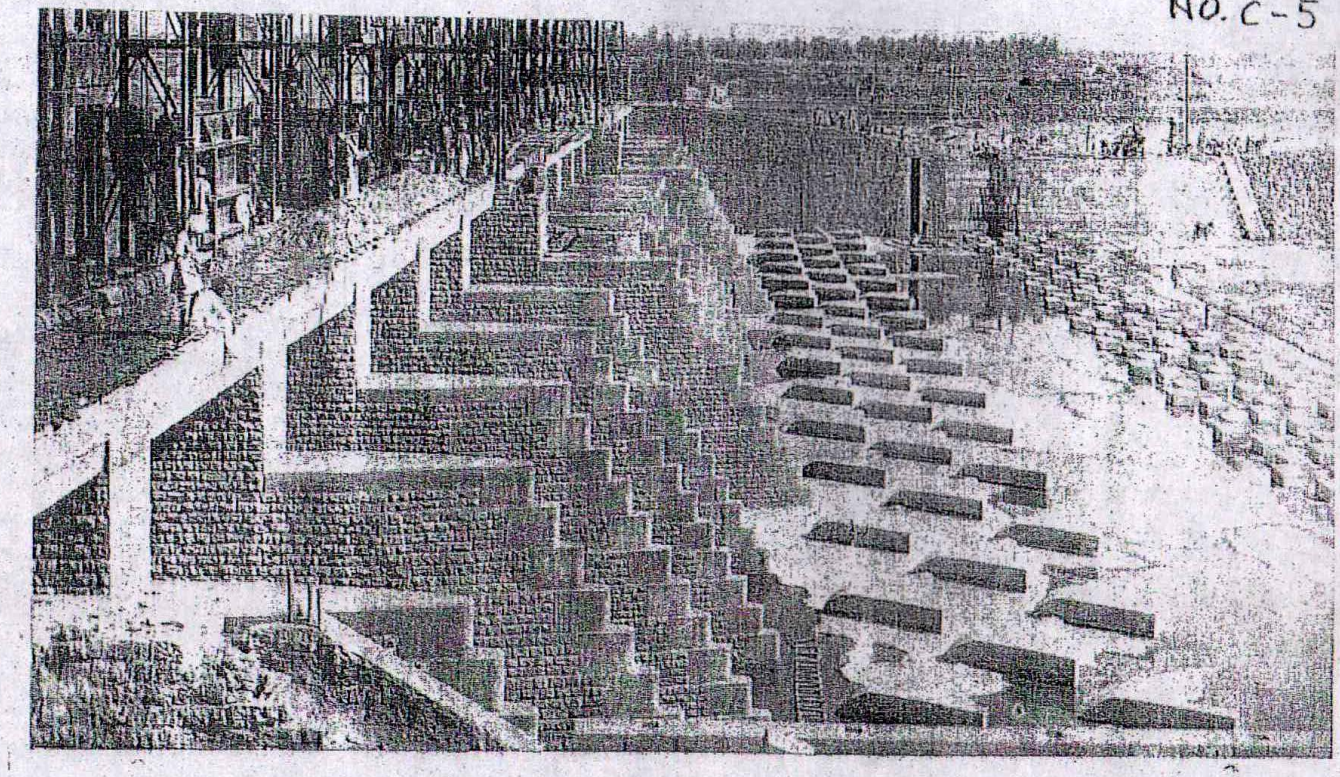
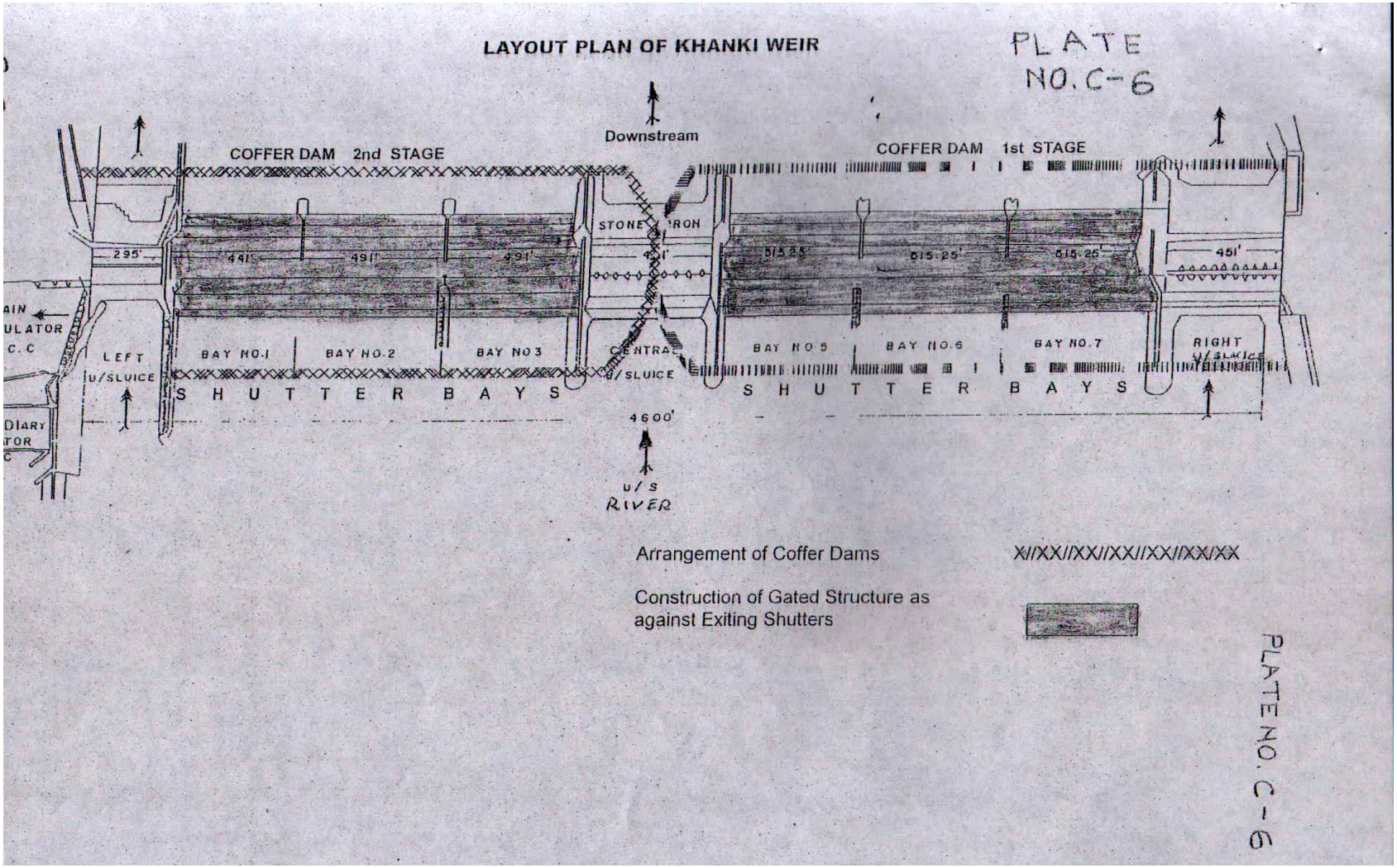

PLATE NO. C-4
FIG: 7
R.L.749
OLD PIER No. 4
R.L.741
NEW R.ABUTMENT (BAY 4)
SHUTTER BAYS CREST R.L.727
R.L.722
R.L.714
UNDER SLUICE BAYS
R.L.715 CREST
1:2.4
1:4:8
R.L.709
R.L.708
1:3:6
R.L.707
CROSS SECTION
SHOWING JUNCTION OF NEW WORK WITH LOW FOUNDATIONS TO OLD WORK WITH HIGH FOUNDATIONS.
SCALE 1/200
30' PILES
15' PILES
BOTTOM RLG94
BOTTOM RL689
OLD WORK
NEW WORK
COARSE SAND
R.L.702
SAND AND KANKAR
R.L.696.5
RED CLAY
R.L.694
CLAY WITH SAND
R.L.681
FIG: 10

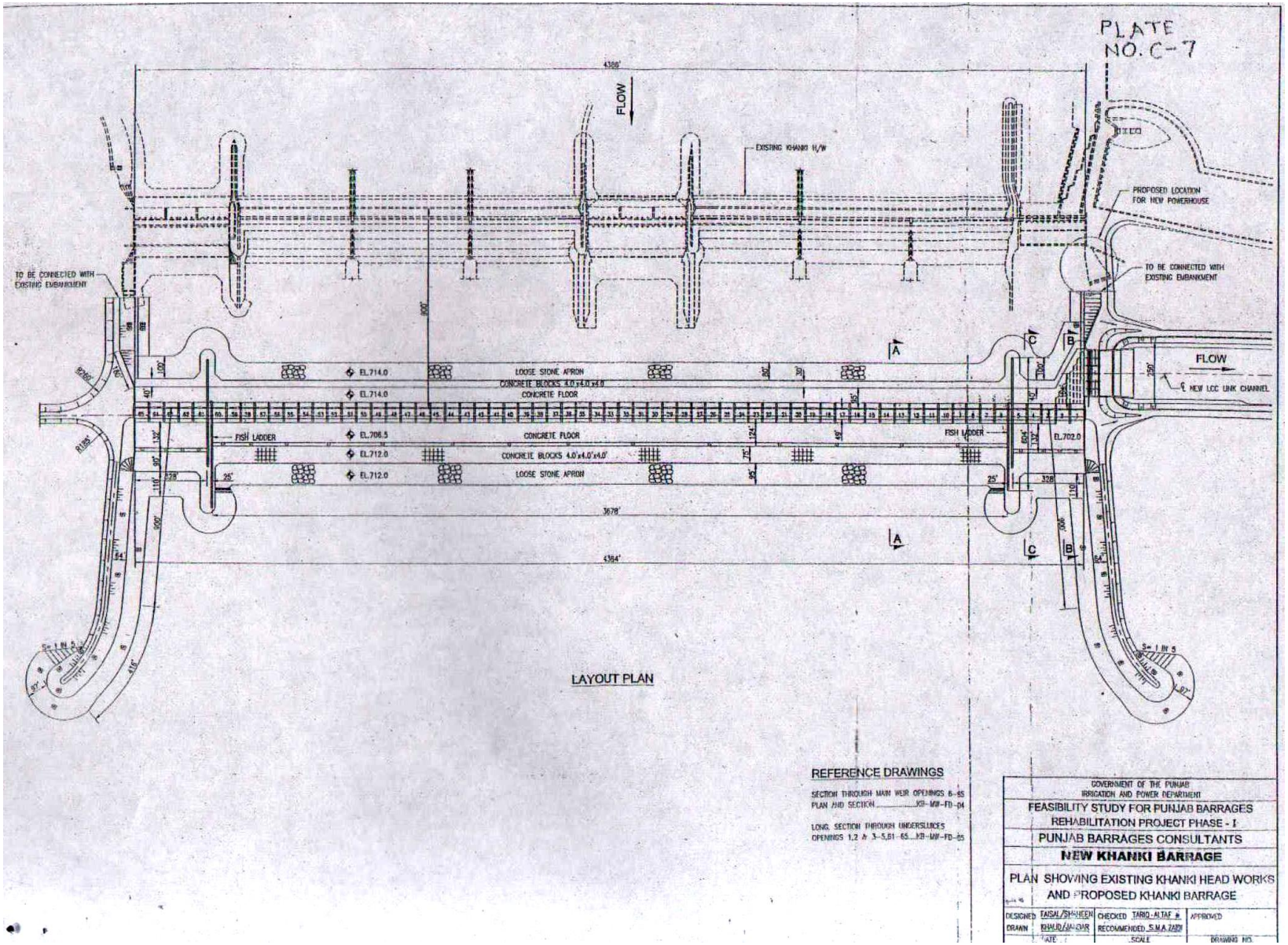
PLATE NO. C-5

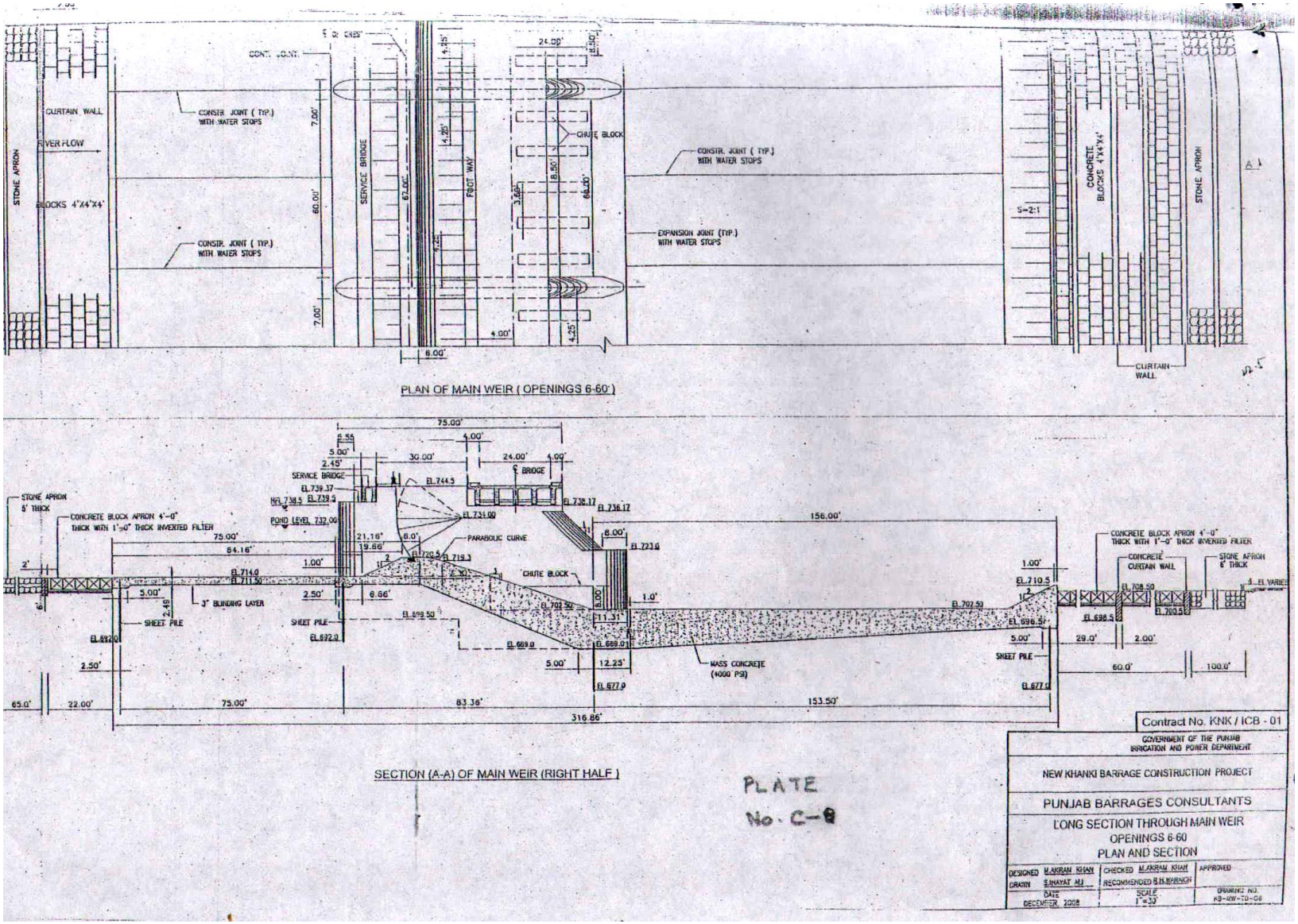


Showing steel work, trough bridge, stepped fish tails of piers, arrows, raised blocks and development from vertical to 1.5 by stepped blocks.

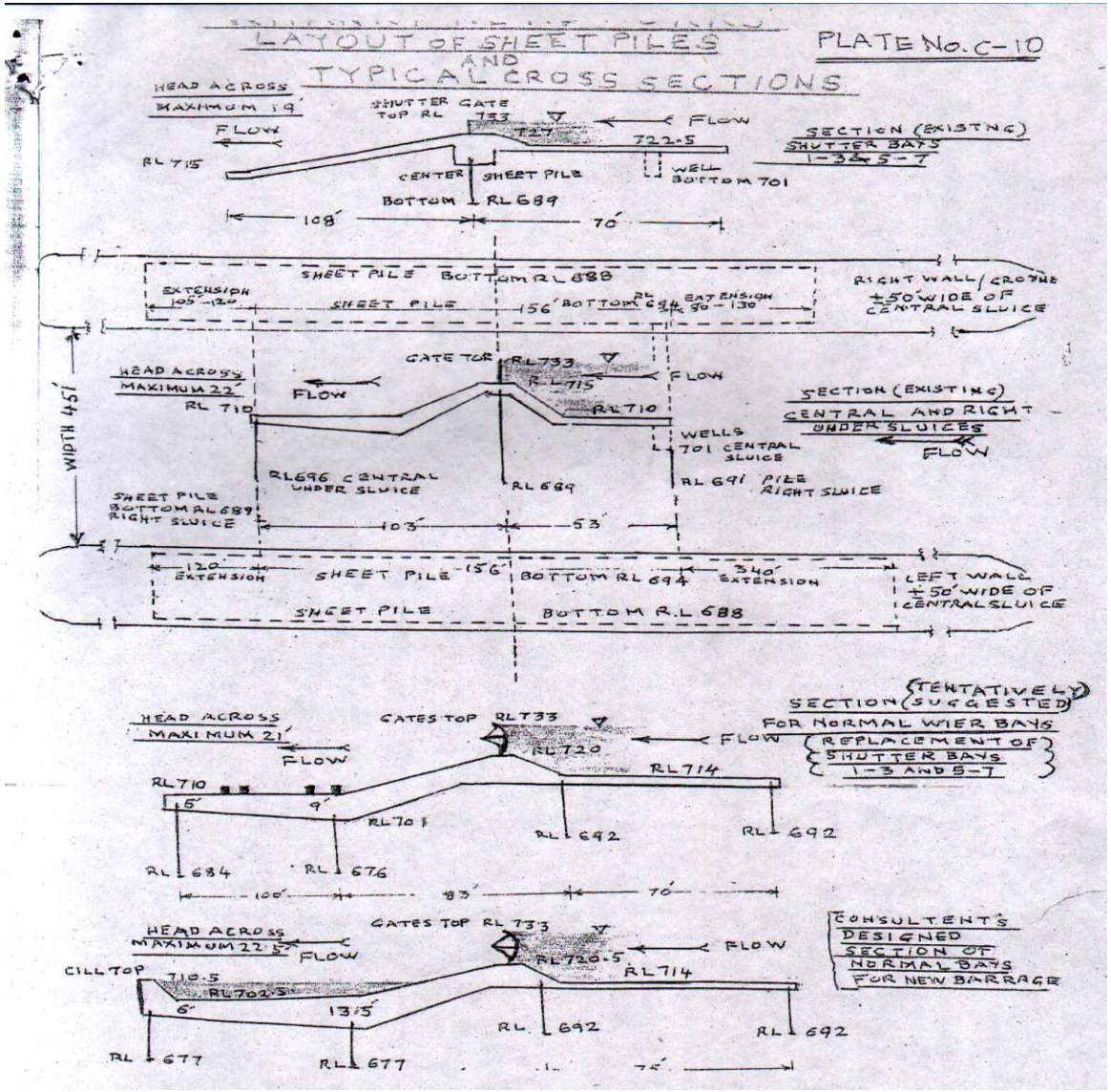
PLATE NO. C-5

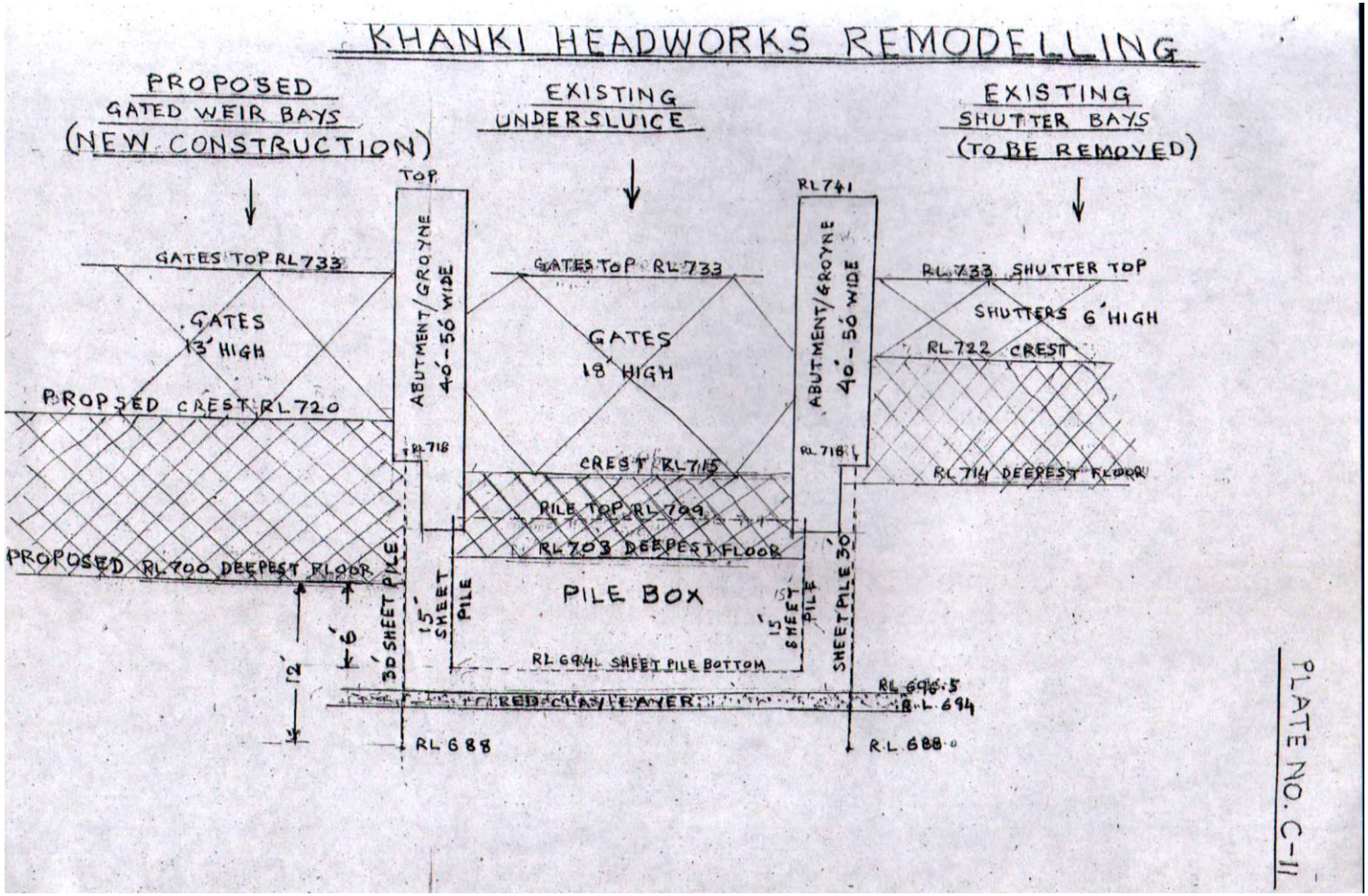

LAYOUT PLAN OF KHANKI WEIR
PLATE NO. C-6
Downstream
COFFER DAM 2nd STAGE
COFFER DAM 1st STAGE
STONE
IRON
295'
491'
491'
491'
491'
515.25'
515.25'
515.25'
451'
LEFT U/SLUICE
BAY NO.1
BAY NO.2
BAY NO.3
CENTRAL U/SLUICE
BAY NO.5
BAY NO.6
BAY NO.7
RIGHT U/SLUICE
S H U T T E R B A Y S
S H U T T E R B A Y S
4600'
U/S RIVER
Arrangement of Coffer Dams
Construction of Gated Structure as against Exiting Shutters
PLATE NO. C-6


PLATE NO. C-7
FLOW
EXISTING KHANKI H/W
PROPOSED LOCATION FOR NEW POWERHOUSE
TO BE CONNECTED WITH EXISTING EMBANKMENT
TO BE CONNECTED WITH EXISTING EMBANKMENT
FLOW
NEW LCC LINK CHANNEL
EL.714.0 LOOSE STONE APRON
CONCRETE BLOCKS 4.0'x4.0'x4.0'
EL.714.0 CONCRETE FLOOR
FISH LADDER
EL.706.5 CONCRETE FLOOR
EL.712.0 CONCRETE BLOCKS 4.0'x4.0'x4.0'
EL.712.0 LOOSE STONE APRON
FISH LADDER
EL.702.0
4386'
3678'
4384'
LAYOUT PLAN
REFERENCE DRAWINGS
SECTION THROUGH MAIN WEIR OPENINGS 6-65
PLAN AND SECTION KB-MW-FD-04
LONG. SECTION THROUGH UNDERSLUICES
OPENINGS 1,2 & 3-5,61-65 ... KB-MW-FD-05
GOVERNMENT OF THE PUNJAB
IRRIGATION AND POWER DEPARTMENT
FEASIBILITY STUDY FOR PUNJAB BARRAGES
REHABILITATION PROJECT PHASE - I
PUNJAB BARRAGES CONSULTANTS
NEW KHANKI BARRAGE
PLAN SHOWING EXISTING KHANKI HEAD WORKS
AND PROPOSED KHANKI BARRAGE
DESIGNED FAISAL/SHAHEEN
CHECKED TARIQ-ALTAF
APPROVED
DRAWN KHALID/ANWAR
RECOMMENDED S.M.A ZAIDI
DATE
SCALE
DRAWING NO.


STONE APRON
CURTAIN WALL
RIVER FLOW
BLOCKS 4'X4'X4'
CONSTR. JOINT (TYP.) WITH WATER STOPS
SERVICE BRIDGE
FOOT WAY
CHUTE BLOCK
EXPANSION JOINT (TYP.) WITH WATER STOPS
CONCRETE BLOCKS 4'X4'X4'
S=2:1
PLAN OF MAIN WEIR (OPENINGS 6-60')
CONCRETE BLOCK APRON 4'-0" THICK WITH 1'-0" THICK INVERTED FILTER
3" BLINDING LAYER
SHEET PILE
PARABOLIC CURVE
MASS CONCRETE (4000 PSI)
CONCRETE CURTAIN WALL
SECTION (A-A) OF MAIN WEIR (RIGHT HALF)
PLATE No. C-8
Contract No. KNK / ICB - 01
GOVERNMENT OF THE PUNJAB IRRIGATION AND POWER DEPARTMENT
NEW KHANKI BARRAGE CONSTRUCTION PROJECT
PUNJAB BARRAGES CONSULTANTS
LONG SECTION THROUGH MAIN WEIR OPENINGS 6-60 PLAN AND SECTION
DESIGNED M.AKRAM KHAN
DRAWN S.HAYAT ALI
CHECKED M.AKRAM KHAN
RECOMMENDED S.E.(C) BRANCH
APPROVED
DATE DECEMBER 2008
SCALE 1"=30'

Layout of Sheet Piles & Typical Cross-Sections




KHANKI HEADWORKS REMODELLING
PROPOSED
GATED WEIR BAYS
(NEW CONSTRUCTION)
EXISTING
UNDERSLUICE
EXISTING
SHUTTER BAYS
(TO BE REMOVED)
TOP
RL 741
GATES TOP RL 733
GATES
13' HIGH
PROPSED CREST RL 720
ABUTMENT/GROYNE
40'-50' WIDE
RL 718
GATES TOP RL 733
GATES
18' HIGH
CREST RL 715
PILE TOP RL 709
RL 703 DEEPEST FLOOR
PILE BOX
RL 694 SHEET PILE BOTTOM
RL 733 SHUTTER TOP
SHUTTERS 6' HIGH
RL 722 CREST
RL 714 DEEPEST FLOOR
PROPOSED RL 700 DEEPEST FLOOR
30' SHEET PILE
15' SHEET PILE
6'
12'
RED CLAY LAYER
RL 696.5
RL 694
RL 688
RL 688.0
PLATE NO. C-11