CHAPTER – VI

DESIGN ASPECTS

6.0 General

The Kosi–Mechi intrastate link canal envisages diversion of part of surplus water of Kosi river for extending irrigation in new command areas of Mahananda basin by way of extending the existing Eastern Kosi Main Canal (EKMC) beyond its tail end at RD 41.30 km upto river Mechi. The main components of the link project are:

1. Existing Hanuman Nagar Barrage and Left Bank Head Regulator
2. Existing EKMC of entire length after its remodelling.
3. New canal beyond EKMC.

6.1 Details of existing Hanuman Nagar barrage on river Kosi

The Hanuman Nagar barrage was designed for a maximum flood discharge of 26,900 cumec. The total length of barrage is 1149 m with 56 number of bays, out of which 6 number are kept under left sluice, 46 number on spillway and 4 number are under right sluice. The length of under sluice bays is 18.288 m each. The crest levels of under sluices and spillway are 70.12 m and 71.64 m respectively. The optimal pond level of barrage is kept as 74.67 m and pond level at the ultimate stage is kept as 77.72 m. There are 6 number of silt excluder tunnels, out of which 4 number are on left side and 2 number on right side of barrage. For energy dissipation, stilling basin with friction blocks of 27.28 m length are provided. The highest flood level of river Kosi at barrage is 79.268 m. The length of raft is kept as 54.88 m whereas the length of upstream divide wall is of 134.61 m long. There are two Head regulators, provided on each bank of Kosi river. The Western Kosi Main Canal offtakes from the right Head regulator and the Eastern Kosi Main Canal offtakes from the left Head regulator. The Kosi-Mechi intrastate link canal is the extension of existing Eastern Kosi Main Canal after its remodelling beyond tail end at RD 41.3 km and escape channel of 2.9 km. As per the proposal, the link canal will offtake from the left Head regulator of existing Hanuman Nagar Barrage. Since the existing Hanuman Nagar barrage was constructed for a peak

discharge of 26990 cumec and is still in working condition and performing very well, hence the design of barrage has not been felt necessary.

6.2 Head regulator

The existing left head regulator at Hanuman Nagar barrage is 98.17 m long with 7 no. of gates of size 12.195 m wide. The design discharge of each gate is 85 cumec whereas the existing pond level of Hanuman Nagar Barrage is kept as 74.67 m and the designed pond level is 77.724 m.

6.3 Link canal

The Kosi–Mechi intrastate link canal is proposed to offtake from left Head Regulator of Hanuman Nagar Barrage located at Indo-Nepal border near Hanuman Nagar town in Nepal. The total length of link canal is 117.50 km. Out of this, 41.30 km is existing EKMC and balance 76.20 km is proposed as new canal. The existing EKMC will need to be remodelled to carry maximum designed discharge of 573 cumec including discharge required for new canal. The canal is designed in 9 reaches upto RD 107.50 km depending upon successive reduction in the designed discharges. A Number of cross drainage structures and various road bridges are proposed on the enroute of the canal, which are described in the following Paras:

6.3.1 Canal alignment

The alignment of the proposed Kosi–Mechi intrastate link canal beyond river Parman, is carried on the basis of actual field surveys. The alignment consists of straight lines and circular curves as per clause of IS Code 5968: "Guidelines for planning and lay out of canal system". Keeping in view these guidelines, all the curves in the new proposed canal of Kosi-Mechi link have been made.

The EKMC and its extension beyond Parman river at RD 44.20 km and the new proposed canal upto RD 117.50 km are gravity canals throughout in its length. The proposed canal alignment passes through full cutting, partial cutting partial filling and in full filling. The canal crosses a number of rivers, roads, canals, distributaries, railway line etc., therefore, provisions of CD structures have been made at each crossing. Four no. of Head and Cross Regulators at various reaches have been proposed. Escape channels have also been proposed along the link canal in various reaches

wherever it is necessary for safety of canal. The radius of curves of escape channel is given in Table 6.1.

Table 6.1

Radius of curves for channel

Sl. No.	Discharge (cumec)	Radius (m)
1	280 and above	900
2	Less than 280 to 200	750
3	Less than 200 to 140	600
4	Less than 140 to 70	450
5	Less than 70 to 40	300
6	Less than 40 to 10	200
7	Less than 10 to 3	150
8	Less than 3 to 0.3	100

The head losses of all major CD structures have been computed for firming up the link alignment. The list of CD structures showing location, type of CD works, FSL at various points, head losses due to various CD structures etc. are furnished in Annexure 6.1.

The Kosi–Mechi intrastate link canal will finally dropped into river Mechi near village Makhanpur of district Kishanganj of Bihar State at RD 117.50 km. The bed slope of link canal is as 1:11000 between RD 0.00 km to RD 41.30 km while the slope in rest of the length of canal is proposed as 1:12000.

6.3.2 Design discharge of canal at offtake point

The design discharge of entire Kosi–Mechi link is firmed up after taking into account the existing peak discharge of distributary system of EKMC as well as proposed peak monthly water requirement of new command areas. The firming up of various discharge at different RDs are given in Table 6.2.

Table 6.2

Firming up of discharges

Sl. No.	RD in km	Name of canal/branch canal / distributary	Enroute discharge (cumec)	RD wise Utilization (inclusive Losses) (cumec)	Discharge (cumec)
	0.000	Total release at head	0.00	0.00	573
1	2.660	Shiv Nagar distributary	0.91	1.12	573
2	3.440	Phulkaha dist.	6.12	6.18	572
3	3.660	Rajpur Branch canal	76.46	76.47	566
4	4.57	Cross Regulator			489
5	13.350	Murliganj Br. Canal	45.02	45.53	489
6	14.380	Pariahi distributary	1.64	1.70	444
7	18.290	Lalitpur Minor	0.22	0.43	442
8	18.290	Ranipatti distributary	6.40	6.40	442
9	18.290	Bhimpur distributary	0.41	0.41	435
10	21.340	Lalitpur distributary Ex.	1.22	1.38	435
11	23.870	Janaki Nagar Br. canal	101.52	101.65	434
12	23.900	Narpatganj distr. Ex.	0.79	0.79	332
13	28.100	Kharsahi distributary Ex.	4.98	5.16	331
14	28.100	Simarbani distributary	2.10	2.10	326
15	32.190	Bhanaga distributary	2.66	2.83	324
16	34.930	Chakardha minor	0.40	0.51	321
17	39.990	Purnea Branch Canal	85.23	85.44	320
18	41.300	Araria Branch Canal	44.00	44.05	235
19	41.30	Maximum discharge required for new canal			191

It is proposed to line the entire existing Eastern Kosi Main canal including new proposed canal. The transmission losses of entire canal (reachwise) have been worked out as recommended by IS 4745-1964. The details of reach wise canal discharges are given in Table 6.2. The link canal has been designed for nine different reaches as give in Table 6.3.

Table 6.3

Reach wise discharge of Kosi-Mechi link canal

Sl. No.	Reach		Bed slope (1:1.5)	Design discharge (cumec)
	From	To		
1	0.00	4.57	1:11000	573
2	4.57	13.35	1:11000	489
3	13.35	23.90	1:11000	444
4	23.90	39.99	1:11000	331
5	39.99	41.30	1:11000	235
6	41.30	61.00	1:12000	191
7	61.00	80.60	1:12000	122
8	80.60	100.00	1:12000	50
9	100.00	117.50	1:12000	27

6.4 Designs

As stated earlier, the Kosi-Mechi Intra State link will utilize existing Eastern Kosi Main canal after its remodelling to provide water to the new command for irrigation purpose. Keeping in view the economical and technical feasibility of project, studies have been carried out for firming up the utility of existing structures without remodelling as summarized in following paras.

Remodelling of Existing Eastern Kosi Main Canal

While firming up the design parameters of existing canal, the following ground positions were considered.

(i) As explained in Chapter-I Introduction, there is an existing canal power house at RD 3.66 km utilizing a fall of 3.96 m and having an installed capacity of 19.2 MW. The maximum tail water level of this power house is 70.104 m.

(ii) The river Kosi is one of the largest silt carrying river of the world and silt control is a challenging task in irrigation structures. The Water Resources Department, Govt. of Bihar is constructing a settling tank at about 1.07 km RD.

(iii) The existing Eastern Kosi Main Canal is a contour canal providing irrigation south wards. Most of the distributary system of existing Eastern Kosi Main canal is on its right bank. Efforts have been made for the optimum utilization of these structures.

In view of the above, the following provisions have been made while carrying out the design of remodelled canal.

To protect canal power house at RD 3.66 km, the existing design parameters of EKMC such as FSL, FSD and bed slope have been maintained in remodelled section also upto RD 4.57 km .

The bed slope is proposed uniformly as 1 in 11000 upto entire length of existing canal i.e. upto RD 41.30 km and FSD is proposed little greater than existing full supply depth, varying from 4.25 m to 3.5 m. In rest of the link beyond Eastern Kosi Main Canal, the bed slope is proposed uniformly as 1 in 12000. By making such provisions, some of the structures upto RD 4.572 km can be utilized without remodelling. In addition, eight nos. of existing bridges constructed across the drainages and parallel to their canal syphons in existing canal portion, can also be utilized without remodelling.

The following 13 structures will be utilized without remodelling as given in Table 6.4. Remaining structures of existing Eastern Kosi Main Canal are proposed for reconstruction due to considerable variation in canal FSL and FSD. The canal sections for various reaches have been carried out keeping in view of the above ground positions.

Table 6.4

Structures utilizing without remodelling

Sl. No.	Reach (km)	Type of structure	Location
1	**2**	**3**	**4**
1	0.000	Head Regulator	Left bank HR of Hanuman Nagar barrage
2	2.657	Head Regulator	Shivnagar distributary
3	3.353	Head Regulator	Phulkaha distributary
4	3.658	Canal Power House	
5	4.572	Head Regulator	Escape
6	6.744	Bridge Parallel to syphon	Sanjay dhar
7	11.143	Bridge Parallel to syphon	Haya dhar
8	17.922	Bridge Parallel to syphon	Bochaha Dhar
9	23.243	Bridge Parallel to syphon	Sursar nadi
10	27.241	Bridge Parallel to syphon	Kharra Dhar
11	30.945	Bridge Parallel to syphon	Gerua Dhar
12	36.768	Bridge Parallel to syphon	Kajra Dhar
13	40.945	Bridge Parallel to syphon	Sita Dhar

Designs of various components of link canal carried out in the study are given in following paras.

6.4.1 Headworks

As explained earlier, the Kosi–Mechi Intra State link will off-take from the left bank Head Regulator of existing Hanuman Nagar barrage. The existing left bank Head Regulator at Hanuman Nagar barrage is 98.17 m wide with 7 nos. of gates of size 12.195 m width. The design discharge of each gate is 85 cumec. Thus, a total discharge of 595 cumec can be diverted through all the seven gates. Since, the design discharge of link canal is worked out as 573 cumec, which can be diverted through the existing left head regulator by utilizing all the seven gates simultaneously. Hence, no remodelling of existing head regulator is proposed.

6.4.2 Design Aspects of link canal

6.4.2.1 Cross section and lining of canal

The design of canal cross sections have been done as per provisions laid down in IS 10430: 'Criteria for design of lined canals and guidelines for selection of type of lining'. The details are given in Plate 6.1.1 to 6.2.2 in Drawing Volume.

6.4.2.2 Manning's coefficient (n)

As per Cl 4.1.2.1 of IS 10430: 'Criteria for design of lined canals and guidelines for selection of type of lining' the value of "n" may be taken as shown in Table 6.5 given below.

However, the Manning's coefficient is taken as 0.018 to compensate for increased resistance due to curves and for taking into account increased resistance due to deterioration of lining with time.

Table: 6. 5

Value of 'n' considered in lined canals

Sl. No.	Surface characteristics	Value of 'n'		
i)	**Concrete with surface as indicated below**			
a	Formed, no finish/PCC tiles or slabs	0.018	-	0.020
b	Trowel float finish	0.015	-	0.018
c	Gunited finish	0.018	-	0.022
ii)	**Brick/Tile lining**	0.018	-	0.020
iii)	**U.C.R./Random rubble masonry with pointing**	0.024	-	0.026
iv	**Asphalt**			
a	Smooth	0.013	-	0.015
b	Rough	0.016	-	0.018
v)	**Concrete bed trowel/float finish and slopes**			
a	Hammer dressed stone masonry	0.019	-	0.021
b	Coursed rubble masonry	0.018	-	0.020
c	Random rubble masonry	0.020	-	0.025
d	Stone pitched lining	0.015	-	0.017
	Stone pitched lining	0.020	-	0.030
vi	**Gravel bed with side slope characteristics**			
a	Formed concrete	0.02	-	0.022
b	Random rubble in mortar	0.017	-	0.023
c	Dry rubble (rip-rap)	0.023	-	0.033

6.4.2.3 Shape

The shape of the canal has been selected as trapezoidal with rounded corners as per provisions of IS 3873: 'Laying cement concrete/stone slab

lining on canals - Code of practice' for ease in laying of lining. The bed width reduces from head to tail with varying water depth according to discharge.

6.4.2.4 Side Slope

As per Cl 8.1.1 of IS 10430: 'Criteria for design of lined canals and guidelines for selection of type of lining' the side slopes are given in Table 6.6.

Table: 6.6

Recommended side slopes for the lined canals

Sl. No.	Type of soil	Side slope (Horizontal: Vertical)	
		In cutting	In filling
1	Very light loose sand to average sandy soil	2:1 to 3:1	2:1 to 3:1
2	Sandy loam	1.5:1 to 2:1	2:1
3	Sandy gravel / murum	1.5:1	1.5:1 to 2:1
4	Black cotton	1.5:1 to 2.5:1	2:1 to 3.5:1
5	Clayey soil	1.5:1 to 2:1	1.5:1 to 2.5:1
6	Rock	0.25:1 to 0.5:1	0.25:1 to 0.5:1

Note: The above slopes are recommended for depth of cutting/height of embankment upto 6 m. For depth/ height in excess of above, special studies for the stability of slopes are recommended.

The cross sectional details of the link canal are given in Plate 6.

6.4.2.5 Free board

As per Clause 8.2 of IS 10430: 'Criteria for design of lined canals and guidelines for selection of type of lining' the value of free board is considered as per Table 6.7 given.

Table 6.7

Values of free board considered for lined canals

Canal discharge	Free board
More than 10 cumec	0.75 m
Between 3 to 10 cumec	0.60 m
1 to 3 cumec	0.50 m
Less than 1 cumec	0.30 m
Less than 0.1 cumec	0.15 m

The discharge capacity of the canal is more than 10 cumec, therefore, the free board is considered as 0.75 m throughout the length of canal.

6.4.2.6 Bed slope

Bed slope of the link canal has been retained as 1 in 11,000 in existing canal reach upto RD 41.30 km and 1 in 12,000 in new proposed canal.

6.4.2.7 Top width of bank

As per BIS:10430-2000, the general recommendations of top width of the bank are as given in Table 6.8.

Table 6.8

Top width of bank of canal

Discharge (cumec)	Maximum top width of bank (m)	
	For inspection road	For non-inspection bank
0.15 to 1.5	4.0	1.5
1.5 to 3.0	4.0	2.0
3.0 to 10.0	4.0+Dowel	2.5
10.0 to 30.0	5.0+Dowel	4.0
Greater than 30.0	6+Dowel	5.0

The size of dowel is considered as 0.5mx0.5 m. However, the total width of dowel is considered as 2.0 m in the designs.

6.4.3 Description of soil profile along the canal alignment based on pit/auger holes.

Soil samples were collected at a distance of around 4 Km except at locations where sampling was difficult due access or some other valid reasons like large depth etc. At filling sections of canal, representative soil samples in gunny bags were collected around canal alignment for laboratory evaluation for their suitability as construction material. Similarly, wherever significant cutting sections of canal were involved, undisturbed soil samples in core cutters (100 mm dia) were collected for laboratory determination of their Index and engineering characteristics at in-situ density. In all 40 samples, both disturbed and undisturbed samples were collected from different pits except complete filling locations where only disturbed samples were collected. These pits wherever possible, were excavated to various depths along/around the canal by the project authorities for sampling by CSMRS field parties. The canal is generally in full or partial cutting whereas complete filling exits at other locations. Suitable soil available from cutting sections preferably with some plasticity can be used in fill portions of canal. It is suggested to conduct further soil investigations at lower intervals of distance (smaller RDs) during construction stage.

6.4.4 Evaluation of the design parameters based on the samples collected along the canal alignment, borrow area and suggested treatment for problematic reaches.

A) Evaluation of design parameters

The Kosi-Mechi intrastate link canal has been designed in such a way that it carries the combined discharge upto river Mechi and fulfills the enroute irrigation water demands with safety, economy and efficiency. For this purpose the following design-criteria based on the relevant provisions of IS codes, and established design practices is proposed.

1. Non silting non scouring velocities should be generated for efficient sediment transport.
2. The system should be flexible to cater to any combination of requirement of irrigation of enroute command and water transfer
3. The Transmission losses should be minimum.
4. The canal should not overtop its lined section in any reach.
5. Designed discharge should be available all the distributaries at designed water level.
6. Deep cutting or high embankments are to be avoided and cutting and filling should be balanced as far as possible.
7. Head loss due to various structure and section resistance should be minimum and compatible with design etc.,

In addition of above, following sub-criteria based on the relevant provisions of IS codes and established design practices have also been adopted.

i. The designed Alignment should involve balanced cutting and filling.
ii. Deep cutting or high embankments are to be avoided as far as possible.
iii. The canal should not overtop its lined section in any reach.
iv. More than intended head loss should not take place.
v. The design should be for better overall economy
vi. The water loss due seepage and evaporation should be minimum
vii. The bed slope should be such that non silting non scouring velocities are generated.
viii. The design should take into account efficient sediment transport etc

The reach wise comparison between existing parameters and section of existing Eastern Kosi Main canal are given in Table 6.9.

Table: 6.9

Existing EKMC and proposed remodelled canal parameters

Sl. No.	RD in km.	Particulars	Existing Design	Proposed Design
1	0	Design Discharge	425 cumec	573 cumec
		Bed Width	110 m	131.50m
		Canal Depth	3.5 m	3.50 m
		Bed slope	1:11000	1:11000
		Canal section	Unlined	Lined
2	4.57	Design Discharge	302.54 cumec	490 cumec
		Bed Width	79.24m	79.50 m
		Canal Depth	3.35	4.25 m
		Bed slope	1:10000	1:11000
		Canal section	Unlined	Lined
3	13.35	Design Discharge	236.17 cumec	444 cumec
		Bed Width	67.06 m	72.00 m
		Canal Depth	3.35 m	4.25 m
		Bed slope	1:10000	1:11000
		Canal section	Unlined	Lined
4	23.9	Design Discharge	139.14 cumec	331 cumec
		Bed Width	44.20	59.00 m
		Canal Depth	2.9 m	4.00 m
		Bed slope	1:10000	1:11000
		Canal section	Unlined	Lined
5	30.93	Design Discharge	131.71 cumec	331 cumec
		Bed Width (m)	44.20	59.00 m
		Canal Depth	2.75 m	4.00 m
		Bed slope	1:19000	1:11000
		Canal section	Unlined	Lined
6	39.99	Design Discharge	41.05 cumec	235 cumec
	to	Bed Width	20.11m	52.50 m
	41.3	Canal Depth	2.13 m	3.50 m
		Bed slope	1:75000	1:12000
		Canal section	Unlined	Lined

The salient canal parameters are as given in Table 6.10

Table: 6.10

Reachwise canal parameters

Sl. No.	Reach RD (km)	Bed slope	Discharge (cumec)	Depth (m)	Bed width (m)
1	0.00 - 4.57	1 : 11000	573	3.50	131.50
2	4.57 - 13.35	1 : 11000	489	4.25	79.50
3	13.35 - 23.90	1 : 11000	444	4.25	72.00
4	23.90 - 39.99	1 : 11000	331	4.00	59.00
5	39.99 - 41.30	1 : 11000	235	3.50	52.50
6	41.30 - 61.00	1 : 12000	191	3.50	43.50
7	61.00 - 80.60	1 : 12000	122	3.00	36.50
8	80.60 - 100.40	1 : 12000	50	2.30	23.00
9	100.40 - 117.50	1 : 12000	27	2.00	15.00

The detail designs of canal sections are given in Annexure 6.2.1 to Annexure 6.2.9 and the corresponding drawings are given in Plates 6.1.1 to 6.1.4.

6.4.5 Backwater effect

The FSL of canal at tail end (at out fall point of Mechi river) has been worked out as 54.239 m while HFL of Mechi river has been considered as 52.50 m taken from the data available from CWC/WRD, Govt. of Bihar. Hence, the canal FSL is considered 1.739 m above the highest flood level (HFL) of Mechi river.

The study has been considered under two scenarios for diversion of canal water into river Mechi.

Scenario-I: When bed level of Kosi-Mechi link canal is above the HFL of Mechi river.

In this scenario there will be no back water effect. However in case of this study, the canal bed level lies below the HFL of river Mechi. Hence this study is not applicable.

Scenario-II: When bed level of Kosi-Mechi link canal is below the HFL of Mechi river.

In this scenario, the canal flow will be obstructed by river flow and as a result there will be an afflux. Therefore to overcome the back water effect, the related studies have been carried out.

In present scenario, the hydraulic conditions at tail end are the same. The bed level of Kosi–Mechi intrastate link canal at out fall point lies below the highest flood level of river Mechi while the full supply level of link canal is higher than HFL of river Mechi. The HFL of Mechi river at out fall point is computed from the HFL data available from CWC/ WRD, Govt. of Bihar considering Taibpur site on Mahananda located in upstream of confluence of river Mechi and river Mahananda and the Dengraghat site on Mahananda located in downstream from its confluence with river Mechi.

On proportionate basis, the HFL at out fall point, which is just 1.5 Km in upstream of confluence of river Mechi and river Mahananda, works out to 52.50 m. The full supply level of link canal at out fall point is 54.239 m.

Thus the Full Supply Level (FSL) is 1.739 m above the HFL of river Mechi. This difference is considered as governing head which is responsible for canal flow into the river. Studies have been carried out based on the energy level differences. The outcomes are as under.

1. Considering canal bed level as datum i.e. 52.239 m.
2. Specific energy of river Mechi with respect to datum E1 =0.312 m head
3. Specific energy of canal with respect to datum E2 =2.025m head
4. Energy difference ΔE=1714 m head
5. Available governing head for canal flow =1.739 m

Since, the available governing head for canal flow is more than required energy head. Hence, no extra widening of canal section at tail end is required. Further the canal section is having a free board of 0.75 m, which can accommodate the afflux likely.

6.4.6 Transmission losses

Transmission losses are considered at the rate of 0.6 cumec per million sqm of wetted area as per IS Code 4745-1964. The month-wise transmission losses in both scenarios are given in Table 6.11.

Table: 6.11

Month-wise transmission losses

Sl. No.	Months	Transmission losses (MCM)		
		EKMC	New canal	Total
1	June	5.87	4.90	10.77
2	July	6.07	5.06	11.13
3	August	6.07	5.06	11.13
4	September	5.87	4.90	10.77
5	October	6.07	5.06	11.13
6	November	5.87	0.00	5.87
7	December	6.07	0.00	6.07
8	January	6.07	0.00	6.07
9	February	5.48	0.00	5.48
10	March	6.07	0.00	6.07
11	April	5.87	0.00	5.87
12	May	6.07	0.00	6.07
	Total	71.43	25.00	96.43
	Say	**71**	**25**	**96**

From the above, the transmission losses of link canal have been worked out as 96 MCM wherein the transmission losses in Eastern Kosi Main canal and new canal are 71 MCM and 25 MCM respectively. The reach wise details of transmission losses are given in Annexure 6.3.

6.4.7 Details of lining of canal

The thickness of 100 mm for lining of canal is adopted as per provisions of IS 3873: 'Laying cement concrete/stone slab lining on canals - Code of practice'. It is also proposed to deploy a HDPE geo-membrane as per provisions of IS 9698: 'Lining of Canals with Polythene films-code of Practice' behind the lining to further reduce losses. The lining is proposed to be unreinforced. The pressure release arrangements as per provisions of IS 4558 : 1995 'Code of practice for under-drainage of lined canals' are

provided to release water pressure behind lining due to rise in ground water level and canal empty condition.

In the absence of data on the ground water level variation, it is proposed to provide 30% of the canal lined section with pressure release arrangement. The details of under drainage are illustrated in Plate. 6.2.1 in drawing volume – III. The details of mechanical placement of the lining of Kosi-Mechi link project are given in Plate. 6.2.2 in drawing volume – III. The lining shall however be reinforced at the junction of lining with any CD structure on upstream and downstream for a distance of 50 m.

6.4.8 Canal structures across Kosi-Mechi instrastate link canal

A number of structures are proposed in link canal from its offtake point to its outfall in river Mechi. Brief descriptions of these structures are furnished in following paras.

6.4.8.1 Cross regulators / Head regulators

10 nos. of cross regulators will be provided at various locations of link canal for providing design discharge to distributary at required water level. The Cross Regulators are provided for the following functions:

1. To ensure pond level in front of head regulators so that the desired quantity of water may be diverted to the distributary.
2. To enable maintenance of a particular stretch of the canal.
3. To facilitate operation of canal escapes.
4. Efforts shall be made to combine bridges with the canal cross regulators to effect economy.

Head regulator has not been proposed for the distributaries in view of the small discharge to be diverted. Instead the water is diverted to distributary through MS pipe of appropriate diameter. To regulate the flow, a valve is proposed to be provided.

Following design criteria has been adopted for design of canal cross regulators:

1. The cross regulator should cause minimum head loss for water flow through the canal. To fulfill this criteria sufficient waterway of the cross regulator shall be provided.

2. The head regulator should be able to dissipate energy satisfactorily in the partial flow. To fulfill these criteria, stilling basin shall be provided.

3. The cross regulator should be able to withstand the uplift pressure. To fulfill these criteria, thickness of floor as well as pressure release valves shall be provided.

4. The cross regulator should be able to prevent piping. To fulfill this criteria sufficient length of floor is provided and cutoff wall is provided. A conservative approach is taken for a later possibility that the canal lining gets damaged at the junction of cross regulator and there is no water on the downstream side of the cross regulator.

5. Upstream and Downstream protection. The cross regulator should be strong enough to with stand the various hydraulic forces due to water flowing over and below it. To fulfill these criteria, sufficient reinforcement shall be provided. The flexible protection is not provided as the canal is fully lined. However the canal section is reinforced on the upstream and downstream for a distance of 50 m.

There are 10 Cross Regulators and 28 Head Regulators altogether proposed across the link canal. Out of which, 3 nos. of existing HRs from RD 0.0 to 4.572 km will be utilized without remodelling. The sample design of cross regulator and sample design of distributary head regulators proposed at RD 61.00 km, RD 23.905 km and at RD 111.00 km are given in Annexure 6.4.1 to 6.4.6 of Annexure Volume. The plan and cross section of the cross and head are appended as Plate 6.3.1 to 6.3.5 in Drawing Volume.

6.4.8.2 Gates for cross regulators

The cross and head regulators shall be at various locations of link canal having Fixed Wheel Type Vertical Lift type service gates in each cross regulator. Size of service gates shall be 3000 mm X 3500 mm. The service gates shall be provided with downstream skin plate and downstream sealing's. Wedge type seal shall be provided for bottom sealing and music note solid bulb seals shall be provided for side sealing's. The seal shall remain in contact with stainless steel seal seats to make the gate water tight. The gate structure shall consist of skin plate stiffened by vertical stiffeners and horizontal girders. The horizontal girders shall be supported by end

vertical girders on each side. The water thrust will be transferred to concrete structures from the end vertical girder through wheels and wheel track. The wheels shall be mounted on self lubricating antifriction bearings. The wheel shall be made up of corrosion resistant steel. The BHN of wheel track shall be 50 BHN higher than the wheel material. 20 mm guide and two numbers guide shoes shall be provided on each side to guide the gate in grooves. The gates shall be operated by rope drum hoist of suitable capacity. The Rope Drum Hoist shall consist of hoist machinery mounted on hoist support structure. Each hoist machinery will be equipped with two rope-drums, gears, pinions, couplings, shafts, worm reducer, motor and brakes. The hoist bridge shall be supported on trestles. One set of stop logs having two units shall be provided to carry out the maintenance of service gates. The stop logs shall be provided with downstream skin plate and downstream sealing's. The stop logs shall be operated in balanced water head conditions. However, the top most units can be lifted under unbalanced water head for one unit height water head. The stop logs shall be operated with monorail crane. The stop log units shall be stored in stop log groove above MWL. The stop log units shall have bronze pad sliding on stainless steel track. 20mm guide shall also be provided to guide the stop log units. Drawing showing details of cross regulator service gates of 3000 mm x 3500 mm.

6.4.9 Structure at the beginning of Kosi-Mechi intrastate link canal

The silt excluder has already been defunct. To overcome the silt problem in Eastern canal ,the Govt. of Bihar is constructing a settling basin in initial reach commencing at RD 1.067 Km. The settling basin is designed to arrest the suspended particles of size larger than 0.071 mm. The total length including transitions is 1517.875 m while the maximum width in middle is 292 m. The velocity of flow in the basin is 0.4 m/sec and the settling velocity of particles is considered as 0.5 m/sec. The average per litre sediment load in design of settling basin of EKMC has been adopted on the basis of design of settling basin carried out by WRD, Government of Bihar and details are as under:

Coarse	0.2910 gm/litre
Medium	0.25896 gm/litre
Fine	1.5306 gm/litre

6.5. Performance of settling basin

The above settling basin is under construction. As per the enquiries made with the officials of WRD, Govt. of Bihar, Birpur, it came to be known that in 2013, the canal was started without full completion of the construction works, and excellent results were observed. The estimated silt was fully controlled. Keeping in view the enhanced discharge of Kosi-Mechi link, the above settling tank is proposed to be remodelled by maintaining the same settling velocities. The plan and L-section of remodelled settling basin are furnished in Plate 6.4.1 to 6.4.4 which is appended in Drawing Volume. The design of remodelled settling basin is given in Annexure 6.5.

6.6 Cross drainage works

The Kosi-Mechi link canal is predominantly contour canal. It crosses several streams, minor/major rivers and several roads. The type of cross drainage works depend upon the catchment area of the streams and its bed level with reference to the bed level of the canal it crosses.

A minor bridge shall be combined with every Aqueduct, Syphon Aqueduct and Cross Regulator to ensure at least one passing over. Besides, other independent bridges are proposed across the length of the link canal. The brief description of the structures provided in Kosi-Mechi link canal is as given below:

6.6.1 Syphon and Syphon aqueducts

Syphon aqueduct has been provided if the HFL of the drain is higher than the canal bed. Canal syphon has been provided if the FSL of the canal is sufficiently above the bed level of the drainage trough, so that the canal can flow under syphonic action under the trough. However while deciding the canal syphon or syphon aqueduct other factors like topography of the terrain, regime of the stream, dewatering requirements, ratio of design flood of drainage to canal discharge, head losses and sediment load in drainage etc have also been considered. Following CD/CM works are proposed across the Kosi-Mechi link canal. Wherever practical, syphon

aqueduct is preferred over canal syphon for lower head loss. Considering the practicability, the following nos. of canal syphons and syphon aqueducts have been proposed.

1	Canal syphons	9 Nos
2	Syphon aqueducts	14 Nos

The designs of syphons are furnished in Annexure 6.6.1 to 6.6.3 and the sample drawings of canal syphons proposed on Sanjay Dhar (RD 6.744km), Haiya Dhar (RD 11.143 km) and on Kajra Dhar (RD 36.768 km) are given in Plate 6.5.1 to 6.5.3. The designs of syphon aqueducts are furnished in Annexure 6.7.1 to 6.7.3 and the sample drawings of syphon aqueducts proposed on river Parman (RD 44.204 km), river Tehri (RD 55.15 km) and on river Ratwa/Gerua (RD 89.300 km) are given in Plate 6.6.1 to 6.6.3.

6.6.2 Canal escape

7 nos. of escape are proposed in Kosi–Mechi Intra State link project at various reaches. The escapes are provided to take care of the vulnerable embankment reaches, to divert the canal flows into the nearby stream in case of any danger of breach in embankment.

6.6.3 Hume pipe culvert

9 nos. of hume pipe culverts proposed in the main link canal. The design details have been furnished in Annexure 6.8.1 to 6.8.3 and the sample drawings of hume pipe culvert proposed at RD 46.040 km, RD 61.050 km and at RD 115.150 km are given in Plate 6.7.1 to 6.7.3 of Drawing Volume-III.

6.6.4 Bridge

Total 42 road bridges are proposed along the length of the canal. Loss of head of 0.015 m is considered at each bridge. Typical design of road bridges at RD 47.266 km, RD 79.247 km and at RD 104.905 km has been carried out as given in Annexure 6.9.1 to 6.9.3 and drawing is given in Plate 6.8 of Drawing Volume-III.

6.6.5 Infrastructure studies

Almost entire area of the project is well connected with road and railways net work. No constraints on transportation of heavy equipment upto project site are envisaged as the area is well connected by NH-57 which can bear class-A loading. The weights of generating units, power transformers and other components etc to be transported by road or from the nearest railhead to project site shall be within the transport limits of 70 tonnes.

6.7 Instrumentation

The requirements of special instruments for the construction of canals are described in other chapters.

6.8 Navigation and tourism development

There is no provision for development of navigation aspect in the project

6.9 Operation and maintenance

The proposed organizational set up at the construction stage can be made available for operation and maintenance of the project. The entire operation and maintenance will be looked after by one chief Engineer along with sufficient organizational set up. A suitable operation and maintenance programme has to be developed for meeting the various objects of the project.