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DESIGN OF FLOOD EMBANKMENTS ON KATJURI RIVER AT CUTTACK CITY

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ABSTRACT

Cuttack city in Orissa state is situated between Katjuri and Mahanadi rivers. There was a proposal to extend the protective embankments along these rivers at the western side of the city. The effect of these embankments on the flood heights and discharge distribution in various arms of Mahanadi river was required to be ascertained. Hydraulically efficient and economically cheaper alignment of these embankments was evolved on the basis of model studies conducted at the CWPRS. A change in the original alignment was recommended to ensure that present flood heights and discharge distribution remains unaffected.

1. INTRODUCTION

Cuttack city in Orissa state is situated between the two arms of river Mahanadi below Naraj namely Katjuri and Mahanadi rivers Fig. 1.

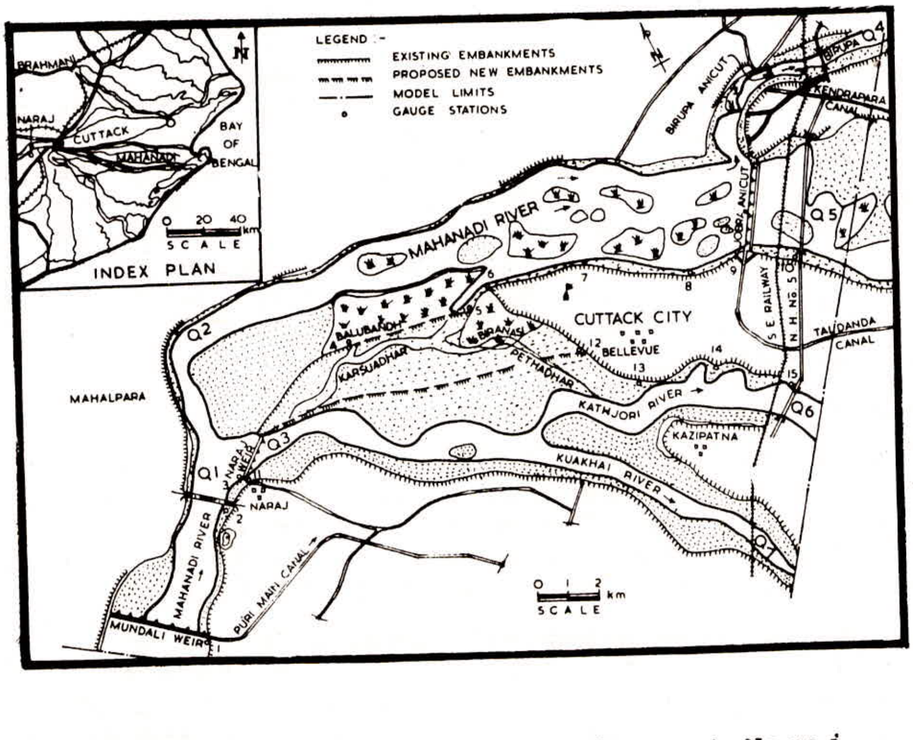

Fig. 1 Plan of Mahanadi river at Naraj.

There was a proposal to extend the protective embankments at the far western side of the Cuttack city from Bidanasi to Balubandh on the right bank of the Mahanadi and

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from left abutment of Naraj Weir to Bellevue gauge site on the left bank of Katjuri river. The proposed embankments are shown in fig.1. In this area there are two channels viz Petadhar and Karsundhar inter connecting the rivers Mahanadi and Katjuri.It was reported that during low to medium floods water flows from Mahanadi to Katjuri through Petadhar channel which is near Cuttack city. During medium to high floods, water flows from Katjuri to Mahanadi through Karsundhar channel which is near the Naraj Weir. The effect of proposed new embankments on flood heights and discharge distribution in Mahanadi and Katjuri rivers was required to be ascertained. Hydraulic model studies in this connection carried out at the CWPRS are described in the paper.

2. THE MODEL :

Studies were made on the model having horizontal scale of 1/400 and vertical scale of 1/66 which was originally constructed in connection with studies for the design of Mahanadi and Birupa barrages. The model covered a reach of the river Mahanadi and its branches from about two km upstream of Mundali Weir to the road bridges on the National Highway No.5 across Birupa, Mahanadi and Katjuri rivers and upto railway bridge across Kuakhai river. The model had semi-rigid bed made in murum. Reach reproduced in the model is shown in fig.1.

3. MODEL STUDIES :

During the studies for Mahanadi and Birupa barrages, the model was proved for water surface slopes and discharge distribution in the various arms of Mahanadi. No fresh proving studies were therefore considered necessary during the present studies. Model studies were made for discharges at Naraj (Q_1) of 28,320 m3/s, 33,980 m3/s and 42,475 m3/s. Results of studies only for discharge of 42,475 m3/s, which is the design discharge for the new Mahanadi and Birupa barrages and also for the existing embankments along Mahanadi and its branches, are reported in the paper.

3.1 Studies Under Existing Condition :

Studies were made for discharge distribution and water levels in various arms of Mahanadi river. Position of gauges where water level observations were made are shown in fig.1. Results of discharge distribution are presented in fig.2(a) while water surface profiles are shown plotted in fig.2(b).

Observations of flow lines were restricted to Katjuri river as the proposed embankments were encroaching on the flood plains of Katjuri river. Observations were taken to identify areas of active and slack flow. The flow lines are shown plotted in fig.3.

3.2 Studies with proposed embankments in position :

The proposed embankments were laid out in the model as per alignment indicated in fig.1. Observations in respect of discharge distribution and water levels under this condition are included in fig 2(a) and 2(b) respectively, while flow lines are shown plotted in fig. 4.

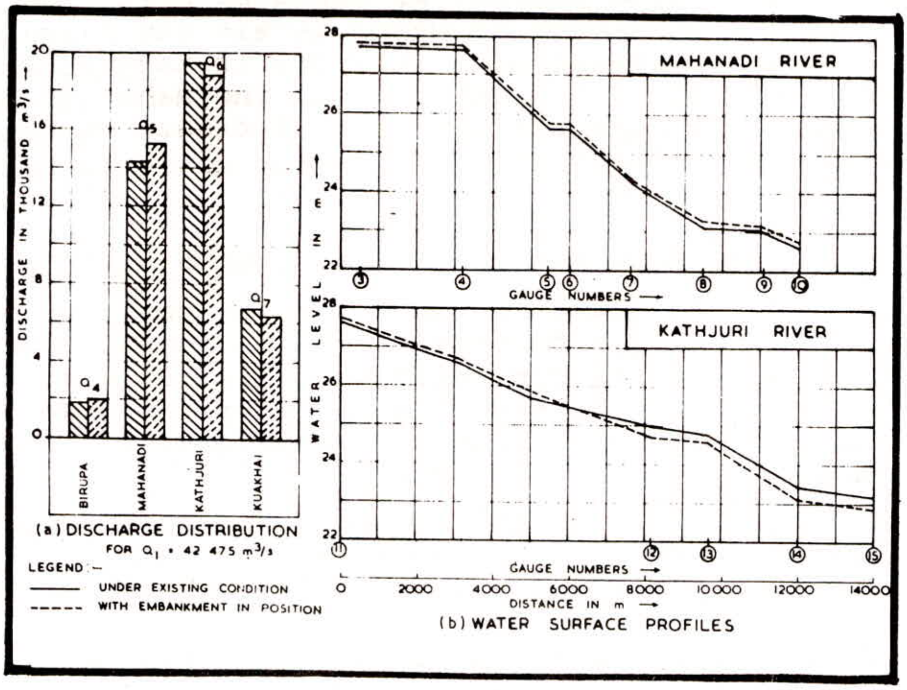
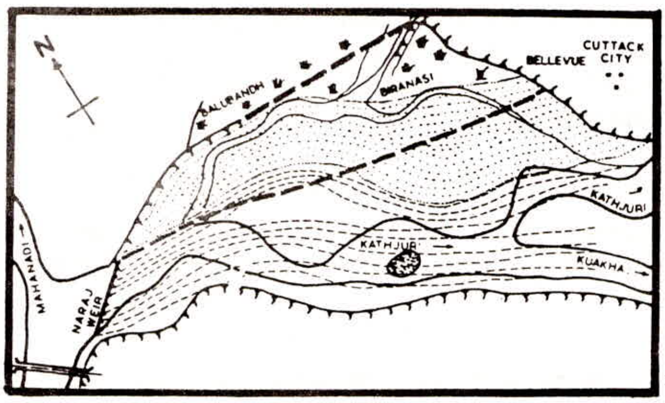


Fig. 2 Effect of Embankment on discharge and water levels.

Fig. 3 Surface flow lines in Katjuri Branch (under existing condition).



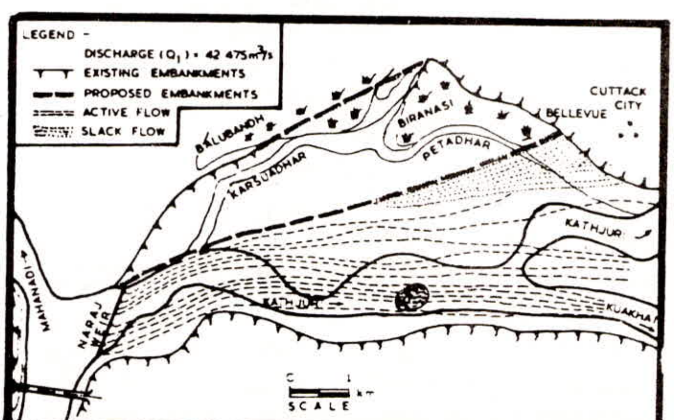


Fig. 4. Surface flowlines in Katjuri Branch (with proposed embankment in position).

It would be seen from the flow lines given in fig. 3 that the proposed embankments in their upstream reach were encroaching on the flood plains. As could be seen from fig.2 this had resulted in increase in water levels and discharge in Mahanadi branch and corresponding decrease in Katjuri branch. The increase in discharge was 885 m3/s at the Mahanadi barrage and 155 m3/s at the Birupa barrage. This increase was about 6.2% and 8.6 % respectively over the design discharge of these barrages.

3.3 Measures to maintain the present discharge distribution :

As stated in para 3.2 there would be increase in discharge at the Mahanadi and Birupa barrages with the proposed embankments in position. This was not considered desirable since construction of these barrages had already been taken up. For maintaining the present discharge distribution following measures were examined.

i) Providing sluices at the mouth of spill channels
ii) Lowering the crest of Naraj Weir
iii) Modifying alignment of the embankment along Katjuri river.

3.3.1 Providing sluices at the mouth of the spill channel :

During the high flood discharge of 42,475 m3/s at Naraj water flows from Katjuri to Mahanadi through Karsundhar spill channel. The quantum of this discharge estimated from the model observations was about 320 m3/s. As stated in para 3.2 the increase in discharge in Mahanadi river was 1000 m3/s (885 + 115). If the sluice is provided at the mouth of spill channel there would still be increase in discharge of 680 m3/s (1000-320) in Mahanadi branch. The sluice at the Karsundhar spill channel was therefore not considered useful.

3.3.2 Lowering the crest of Naraj Weir :

Naraj weir was constructed across Katjuri river in the year 1865 to limit flood flows in the river and to divert low supplies in Mahanadi river. The weir has a crest RL at 22.12 m and a length of 1168.29 m.

To examine the effect of lowering the crest of Naraj weir water levels upstream and downstream of the weir and discharge distribution in Mahanadi and Birupa rivers without the proposed embankments in position were examined. It was observed that the Naraj weir was functioning at submergence ratio of 98.25% for a discharge of 42,475 m3/s.

The Ratios of discharge in Mahanadi branch (Q_2) to that in Katjuri (Q_3) branch for different flood discharges in Mahanadi at Naraj (Q_1) are shown plotted in fig. 5 which indicates that the ratio of Q_1/Q_2 remained practically constant beyond the flood discharge of 26,240 m3/s.

Naraj weir thus was not found to control the discharge distribution in Katjuri and Mahanadi beyond Q = 26,240 m3/s. The discharge distribution is entirely dependent on the geometrical features of the divide between Mahanadi and Katjuri.

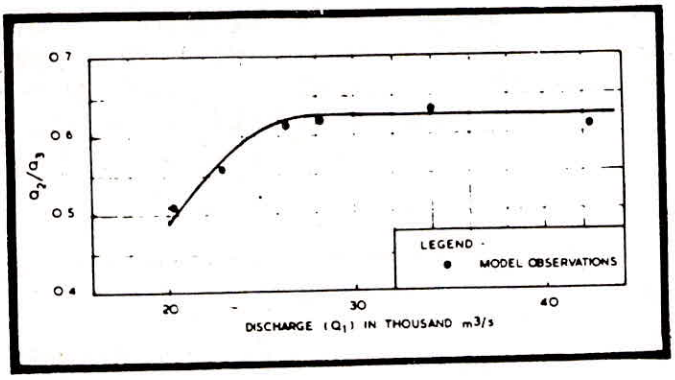


Fig.5 Discharge distribution in Mahanadi at Naraj.

In view of the above, it was concluded that lowering of Naraj weir would not help in maintaining the present discharge distribution under post-embankment conditions. The other alternative appeared to be modifying the alignment of the proposed embankment to achieve the same objective.

3.3.3 Modifying the alignment of the embankment along Katjuri river :

In this connection three alternative alignments were studied .

3.3.3.1 Studies with alternative alignment no. 1 :

Considering the flow pattern given in fig.5, the proposed alignment of embankment along the Katjuri river was receded in the upstream reach where it was earlier encroaching on the flood plain and was advanced in the downstream reach where slack flow was observed (fig. 6 Alignment no.1)

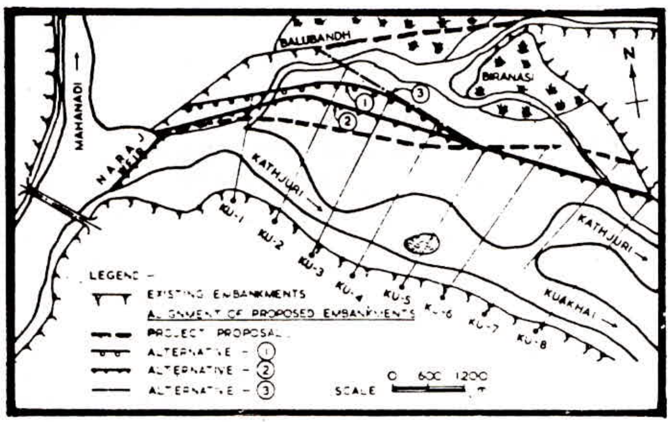


Fig.6 Alternative alignments of flood embankments

No changes were necessary in the alignments of proposed embankment along Mahanadi river. With this alignment, discharge distribution and water levels were found to remain unaffected. Surface velocities at various locations along the embankments observed in the model are shown plotted in Fig.7.

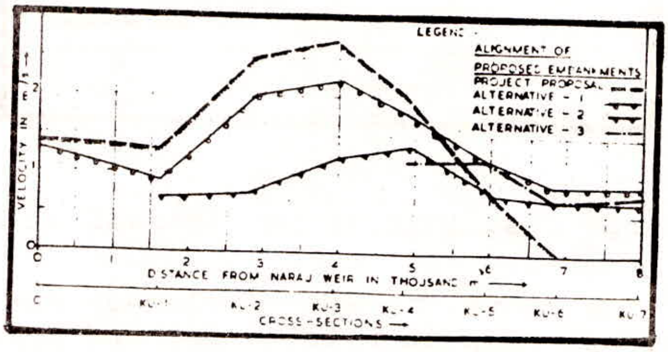


Fig. 7. Velocities along Katjuri embankment.

The maximum surface velocity was observed to be 2.20 m/s.

3.3.3.2 Studies with alternative alignment no.2.

In order to reduce the velocities along the embankments alternative alignment no. 1 was further receded between river cross-sections KU2 and KU4 (fig.6 Alignment 2). Surface velocities along the revised alignment of the embankment are shown plotted in fig. 7. The maximum velocity was found to reduce to 1.40 m/s.

3.3.3.3 Studies with alternative alignment no.3

It was observed that out of total length of 8.70 km of the embankment in alternative 1, the upstream 40% length of 3.8 km afforded protection to only 20% of total protected area. In order to economise the cost, the alignment was further modified (fig.6 Alignment 3). This alignment had a total length of 6.15 km Velocities under this condition are shown plotted in fig.7. The maximum velocity along the embankment was 1.20 m/s. The minimum and maximum distance between the existing embankment on the right bank of Katjuri and proposed embankment on the left bank of the same river, as per this alignment, were 2.20 km and 2.70 km.

3.3.3.4 Comparison of Performance :

A comparison of performance of the original alignment suggested by the Project authorities with that of the three alternatives studied in the model is made in Table -1. It would be seen from Table -1 that the performance of the embankment with alternative alignment no.3 seems to be better as the highest velocity observed along the embankment is minimum, the ratio of area protected to the length of embankment is good and the distance of this embankment from the existing embankment on the right bank is uniform and is about three W Lacey as per Indian design criteria. The embankment with alternative no.3 was, therefore, considered hydraulically effi cient and cheaper and hence was recommended.

TABLE - 1

COMPARISON OF PERFORMANCE

Alignment No.		1	2	3	4
Alignment		Project Proposal	Alt.1	Alt. 2	Alt. 3
% increase in the design discharge at					
(i) Birupa Barrage		8.5	nil	nil	nil
(ii) Mahanadi Barrage		6.2	nil	nil	nil
Maximum velocity in m/s		2.70	2.20	1.40	1.20
Length in km (L)		8.00	8.70	8.55	6.15
Area protected in sq.kms. (A)		7.85	7.70	5.40	5.20
A/L		0.98	0.88	0.75	0.85
Distance between the embankments in mtrs.	Max.	3160 (4.10L)	2530 (3.30L)	1520 (1.60L)	2790 (3.60L)
	Min.	1010 (1.30L)	1260 (1.60L)	1260 (1.97L)	2530 (3.28L)
Remarks					Recommended

4. CONCLUSIONS :

4.1 Alignment of embankment proposed in the project was found to increase design discharges at Mahanadi and Birupa barrages by 6.2% and 8.6% respectively.

4.2 Providing a sluice at the mouth of spill channel or lowering the crest of Naraj weir was not found to be useful in maintaining present discharge distribution under post embankment conditions.

4.3 All the three alternative alignments studied in the model were found to maintain status quo in respect of water levels and discharge distribution. Alternative alignment no.3 was considered hydraulically efficient and cheaper.

5. ACKNOWLEDGEMENT :

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