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OCTOBER 1955—No. 102

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Shri H. P. Mathrani and Shri K. K. Nambiar left for Istanbul on the 24th September.

Six delegates from India attended the Tenth International Roads Congress which was held at Istanbul from the 26th of September.

Shri H. P. Mathrani, Consulting Engineer to the Government of India (Road Development), and Shri K. K. Nambiar, President, Indian Roads Congress & Chief Engineer, (Highways), Madras represented the Government of India. The ether delegates were Shri W. X. Mascarenhas, Chief Engineer, Buildings & Roads, Govt. of Bombay, Shri E. A. Nadirshah, Chief Engineer, Concrete Association of India, Shri W. A. Griffiths and Shri Sujan Singh of Burmah-Shell.

TRANSPORT-COMMUNICATIONS MONTHLY REVIEW

A REVIEW OF
ROAD ENGINEERING, DEVELOPMENT & TRANSPORT

OCTOBER 1955

ARE RIVERS ACROSS ASSAM ACCESS ROAD AND RAIL LINK A CHALLENGE TO ENGINEERS ?

By
Kumud Bhushan Ray

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LIFE LINE OF CIVILISATION

IN his message to the 19th Session of the Indian Roads Congress at Srinagar, our Prime Minister said :

> "Communications of all kinds are essential in any system of planning."

Communication is the life line of civilisation. Communication, between Assam and the rest of India by rail and steamer, was cut off after the creation of East Pakistan in 1947. Since then, an all-weather Assam Access Road and an Assam Rail Link have been constructed. After the great earthquake of 1950, N. E. India appears to be having an annual ordeal by water, every flood season. The Assam Access Road and the Rail Link are snapped in more places than one, so that communication remains cut off for a few months. Considerable expenditure has to be incurred every year to restore communication. The rivers in this region are thus a Challenge to engineers !

LOOP CHANNELS AND DAMAGED BRIDGES

Travelling along the Assam Access Road, one finds several damaged bridges and temporary diversions. The rivers that cross the Assam Rail Link and the Access Road rise from the Himalayas, the main rivers being Teesta, Dharla, Jaldhaka and Torsa. It is noticed that these rivers and their tributaries have many loop channels. For example the Gheesh and Chel, tributaries of the Teesta, are joined together at their source upstream. The Jaldhaka, Torsa and its tributary Kaljani, have many loop channels, which take off upstream and rejoin the parent river downstream. Conditions of flow are further complicated, as many of the loop channels take off from one river upstream and join another river downstream.

It is, therefore, very difficult to determine the high flood discharge, through each one of these tributaries and loop channels. It may happen that the flow through one loop channel goes on increasing, and consequently the flow through another loop channel goes on decreasing. At present, the flow through the several loop channels in a river basin is seldom kept under observation. Thus when the flow through a loop channel increases beyond the capacity of the bridge across it, there is damage to the bridge, or the bridge approaches are overtopped and breached.

VAGARIES OF RIVERS—MANAS RIVER BASIN

The Author had opportunity, in his 31 years' service in the Railways, to observe the several loop channels in the Manas River Basin, Assam. The Manas, Bholookadoba, New Hakua, Old Hakua, Beki, etc.—which are shown in Fig. 1. In 1909, when the railway was constructed in Assam, the Manas Loop Channel carried the main flow of the Manas River Basin, the bridges being :

Manas	Bholookadoba	Baki or Mara (dead) Manas
10 × 100 ft	2 × 75 ft	4 × 12 ft

In 1948, when the aerial survey map from which Fig. 1 has been drawn was made, condition of flow in the Manas River Basin was quite different. The Manas emerges from the foothills at A. Between A and H, the slope of the country is very steep, so that velocity of flow in the river channel is high and hence channel alignment is more or less straight. Below H, due to flatter slope and lesser velocity, erosion of banks developed a tortuous alignment KLMNOP, while the channel became wider and shallower. The longer length in a tortuous alignment flattens the slope of water surface (S.W.S.), while the wider and shallow channel decreases the hydraulic Mean Depth (H.M.D.). As a result, the velocity of flow and consequently the discharging capacity of the Manas Loop Channel gradually decreased, so that it could not accommodate and drain away the discharge of the Manas river basin.

There was backing up and rise of water level upstream so that a part of the water found its way through the shallower but straighter Beki loop channel, to its outfall lower down into the Manas loop. A cataract action, starting at this outfall, dug back and back through the Beki loop, until it reached the railway bridge near G and ultimately upstream at A on the Manas loop, so that a cut-off channel was established. More and more water flowed through the Beki loop, whose channel went on improving, while lesser and lesser water flowed through the Manas loop, whose channel went on deteriorating.

As the deepening in the Beki loop channel reached the railway bridge over it, the 4 × 12 ft span bridge with shallow foundation was undermined and breached. Successive bridges had thus to be provided over the Beki loop channel, from 1909 to 1945 :

(i) 4 × 12 ft

(ii) 4 × 20 ft

(iii) 9 × 20 ft

(iv) 1 × 50 ft, 1 × 30 ft, 6 × 19 ft

(v) 1 × 50 ft, 2 × 20 ft, 6 × 19 ft

(vi) 2 × 40 ft, 3 × 100 ft

(vii) 7 × 150 ft

All this time the Manas loop channel deteriorated, so that in 1945 only 4 × 100 ft out of the 10 × 100 ft spans carried the discharge, while the river bed level rose 14 feet.

In the Beki loop channel also, erosion of banks went on developing a tortuous alignment CDEFG, and caused widening and shallowing of its channel. With gradual flattening of S.W.S. and decrease in H.M.D., there was gradual decrease in velocity of flow and discharging capacity in the Beki loop channel. There was backing and rise of water level in the Beki loop upstream, and water found its way through the Bholookadoba loop channel HQRKS, to its outfall lower down into the Manas loop. A cataract action, starting at this outfall, dug back and back through the Bholookadoba loop, until it reached the railway bridge near S and ultimately upstream at H on the Manas loop, establishing a cut-off channel. More and more water flowed through the Bholookadoba loop, whose channel went on deepening and improving.

When the deepening in the Bholookadoba loop channel reached the railway bridge at S it was undermined and damaged. Successive bridges had thus to be provided

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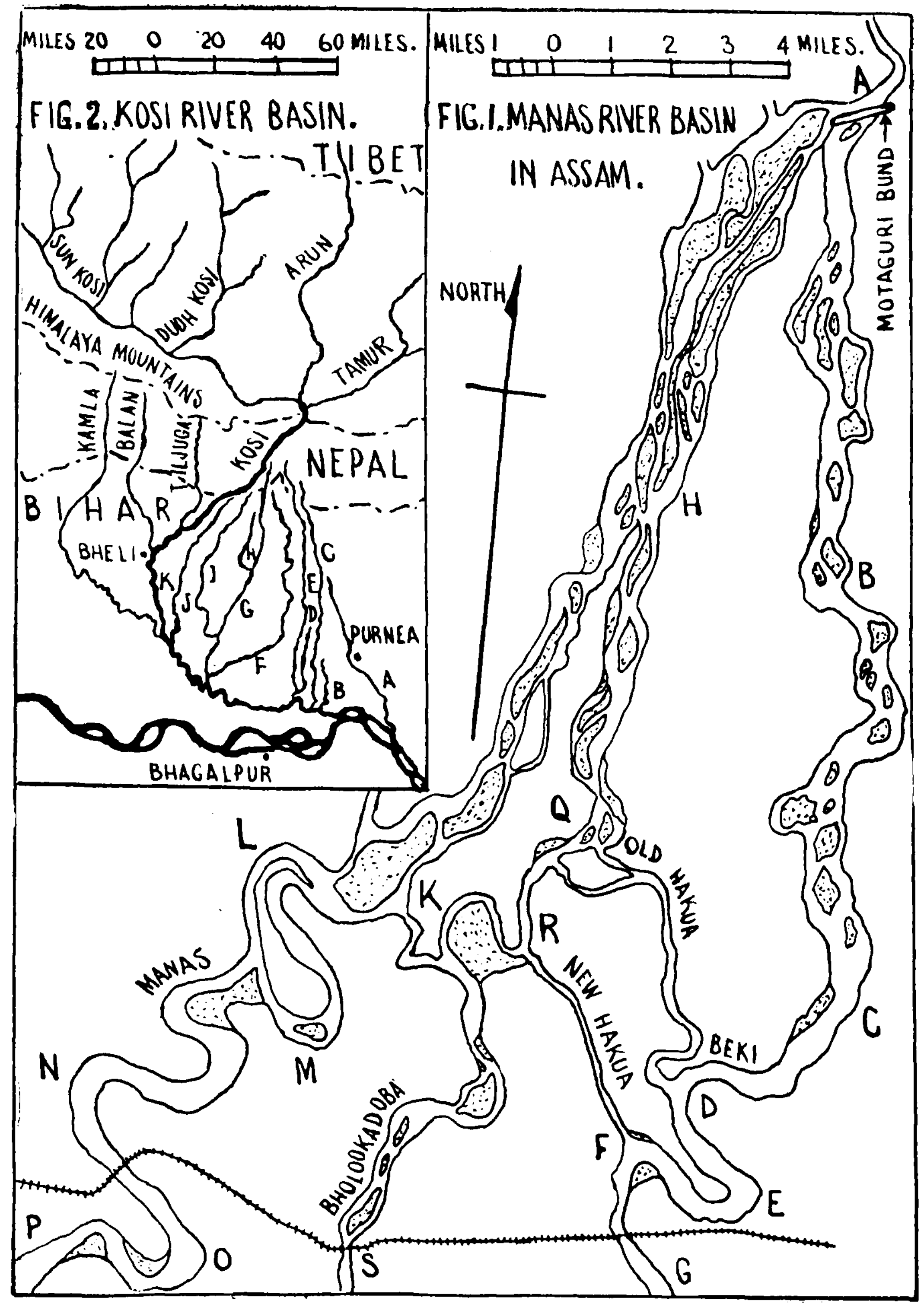


over the Bholookadoba loop channel :

(i) 2 × 75 ft
(ii) 3 × 75 ft
(iii) 1 × 250 ft
(iv) 2 × 150 ft

In 1942, it was decided to divert the flow from the Beki loop to the Manas loop, by building the Motaguri Bund at A. The flow through the reach of the Beki loop was thus checked, there being greater flow through the Manas loop : but as the tortuous and shallow reach KLMNOP of the Manas loop could not accommodate and drain away the increased discharge, there was backing up and rise of water level upstream, water found its way along HQR through the shallow but straighter New Hakua Loop RF, having an outfall at F, avoiding the tortuous reach CDEF in the Beki loop. The cataractaction at F dug back and back along FRQH, establishing a cut-off channel. More and more Manas water flowed through the straighter loop channel AHQRFG, improving it, while the Beki loop ABCD deteriorated. But this object of construction of the Motaguri Bund—diversion of Manas water through the 10 × 100 ft spans over the Manas loop channel—was frustrated.

UNDEVELOPED RIVER BASINS

This frustration gave rise to the belief that the Manas River Basin is undeveloped and hence such vagaries of rivers must continue. This created so much pessimism that there was a proposal to abandon the railway line across the Manas river basin, to have a diversion line from Bongaigaon to Jogighopa, to cross the Brahmaputra by a bridge, and to have a new railway line to Gauhati along the south bank of the river.

There are, however, loop channels in the Torsa, Jaldhaka and Teesta river basins in North Bengal, as already described, in the Kosi river basin in Bihar, in the Yellow River Basin in China, and elsewhere in other countries. The belief in undeveloped river basins cannot, therefore, be correct.

THE KOSI RIVER BASIN

The Kosi river basin has several loop channels, as shown in Fig. 2 :

A. Kali Kosi 1731
B. Livari 1770
C. Dhamdaha 1807-1839
D. Hiran 1840-1873
E. Sursar 1874-1892
F. Mirchai 1893-1921
G. Dhusan 1922-1931
H. Parwane
I. Tilabeh 1926-1948
J. Dhemrah 1933 ·
K. Kosi from 1948.

As explained earlier, erosion of river banks leads to decrease in the discharging capacity of a loop channel, there is backing up and rise in water level, leading to overflow of water away from the channel. River side lands are submerged and there are flood damages.

The former choked up and abandoned Eastern loop channels in the Kosi river basin, are not able to accommodate and drain away the overflow water. Hence, practically the whole of this water finds an outfall into a parallel Western River, where a cataract action starts, digging back and back, and establishing a cut-off channel. More and more Kosi water thus flows through the Western River, which goes on improving while lesser and lesser water flows through the Kosi Loop channel, which goes on deteriorating. In this process, the Kosi loop channel is choked up with silt and is abandoned, while the Western River becomes the New Kosi.

Erosion of river banks continues in the New Kosi. The same process is repeated. Another Western River is improved and becomes the Newer Kosi, while the former New Kosi is choked up with silt and is abandoned. The several loop channels in the Kosi River Basin have thus been formed, and not because the Kosi has an Undeveloped River Basin.

Fig. 2 shows that Kosi waters now flow through the lower reaches of the Tiljuga, Balan and Kamla rivers and there are no more suitable Western River left, through which Kosi overflow water may flow. But erosion of river banks in the present Kosi is progressively deteriorating its channel and progressively decreasing its discharging capacity. This explains how every year flood water level in the Kosi river is rising higher, even when the Kosi is carrying a lower high flood discharge, and there is submergence of agreater area of Kosi river side lands, under a greater depth of water and for a longer period. That this is so will appear from the

maximum discharge in the Kosi river in different years :

Year	Maximum High Flood Discharge In cu.ft.
1927	700,000
1948	470,000
1953	230,000

In this process, the Kosi river is likely to find its way through a former abandoned Eastern Loop Channel in the Kosi river basin. If this has a good outfall, a cataract action through it will improve its channel, and the Eastern Kosi Loop Channel will then become the Kosi.

THE YELLOW RIVER BASIN

Similarly in the Yellow River Basin in China, a former abandoned loop channel G, shown in Fig. 3, is at present the Main Yellow River. A careful record is kept of flow through the many loop channels in the Yellow River Basin : (See fig. 3)

A. 2278 B. C. to 602 B. C.
B. 601 B. C. to 11 A. D.
C. 12 to 1048
D. 1049 to 1194
E. 1195 to 1494
F. 1495 to 1855
G. 1856 to 1938
H. 1939 to 1946
G. From 1947.

EROSION OF RIVER BANKS

Thus erosion of river banks starts a process, by which there is progressive deterioration of a river, with consequent progressive decrease in its discharging capacity, leading to a progressive rise in flood water levels, overflow away from the river channel, submergence of river side lands and flood damages.

When the overflow water finds its way into another abandoned Loop Channel in the river basin, which has a good outfall, then cataract action at the outfall digs back and back through this loop, improving its channel, until a cut-off channel is established. More and more water flows through this Loop Channel, which goes on improving, while lesser and lesser water flows through the former loop channel, which goes on deteriorating. The improving loop channel ultimately becomes choked up with silt and is abandoned. Vagaries of a river are thus caused by erosion of river banks and not because the river basin is undeveloped.

BRIDGE OPENING OVER LOOP CHANNELS

This explains the difficulty in determining the size of bridge openings over the several loop channels in a River Basin. Thus in the Manas River Basin, the bridges provided were.

Year	Manas	Bholookadoba	Beki
1909	10 × 100′	2 × 75′	4 × 12′
1945	10 × 100′*	1 × 250, 2 × 150	7 × 150′

To prevent such development, it is essential that a survey is made of all the loop channels in a river basin. An aerial survey map shows accurately all the loop channels in a river basin, whether flowing partially deteriorated, or choked up and abandoned.

It is of vital importance, when deciding on the waterway to be provided in a bridge over the flowing loop channel, to have ample waterway to pass the maximum discharge of the whole river basin. For the other loop channels in the river basin, only sufficient waterway to pass the discharge from local rainfall should be provided.

MAINTENANCE OF ONE LOOP CHANNEL

This was done in the case of the Manas River Basin, a 10 × 100′ or a 1000 feet waterway being provided over the Manas Loop channel, while only a 4 × 12′ or a 48 feet waterway was provided in the Beki Loop Channel.

But in spite of this, a 7 × 150′ or 1050 feet waterway had ultimately to be provided in the Beki Loop Channel. This

* *Note.* Only 4 × 100′ spans, out of the 10 × 100 were carrying the discharge in 1945, while the bed had risen 14 feet.

FIG. 3.
THE YELLOW RIVER BASIN IN CHINA.

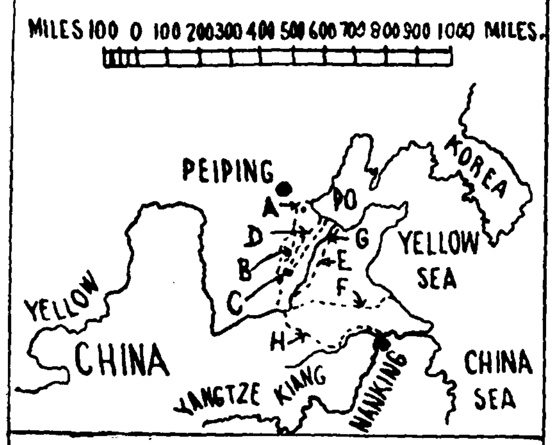


FIG. 4.
"BANDALS" IN A RIVER.

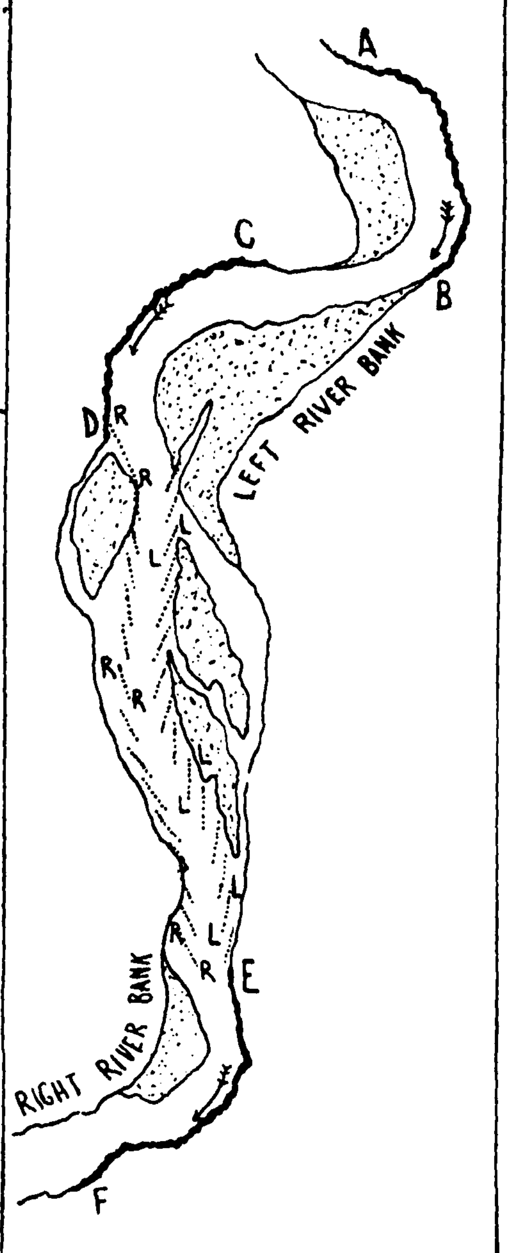
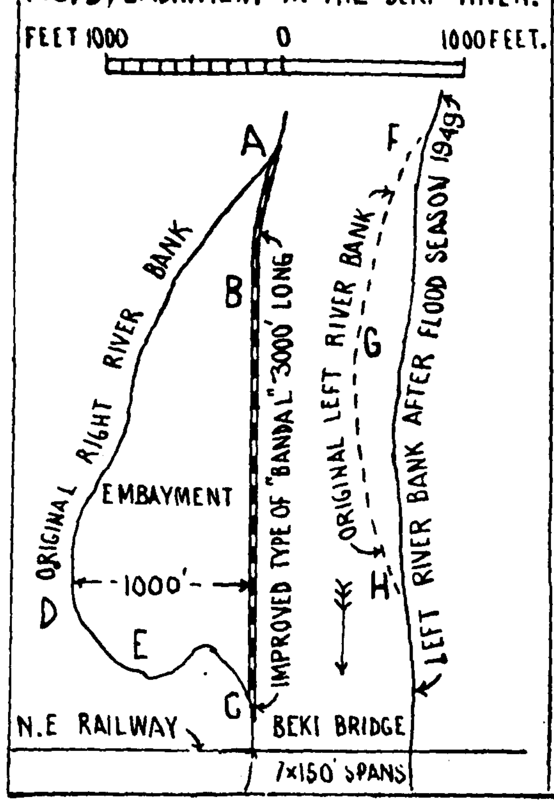


FIG. 5, EMBAYMENT IN THE BEKI RIVER.



happened, because no steps had been taken for the maintenance of the manas loop channel in good order. Uncontrolled erosion of river bank caused derioration in the Manas Loop Channel, decreasing its discharging capacity, so that overflow water from its channel found its way into the Beki Loop Channel, which went on improving, until it became the main loop channel of the Manas River Basin.

Maintenance of one loop channel in a River Basin is, therefore, of vital importance. If steps are taken to maintain one Loop Channel in good order, the channel will not deteriorate, there will be no flow of water away from this Loop Channel into another loop Channel of the river basin. Other loop Channels in the river basin cannot, therefore, improve. With no overflow from the Loop Channel, river side lands are not submerged and there are no flood damages.

"Bandals"—In wide and shallow rivers in Northern India "bandals" have been used by Steamer Companies to maintain navigable depth for steamers. In the dry season, a river flows through comparatively deeper channel in the bends AB, CD and EF, as shown in Fig. 4. The reach DE, connecting two adjacent bends CD and EF, has a straighter alignment, having two or more wider and shallower channels, with islands in between. To maintain steamer service, it is necessary to deepen the channel in the reach DE. By assisting a river to utilise the great force of its current of water—its power of transportation of silt and of erosion of channel surface—this shallower reach is narrowed and deepened.

A "bandal" consists essentially of vertical bamboos, driven in the river bed, along a series of two rows LL and RR fig 4. The current of water in the river is thus guided to flow through the narrowed channel, between the rows LL and RR As a result, the velocity over this part of the channel is slightly increased, while the velocity, over the parts of the channel between LL and RR and the original river banks, is slightly decreased. The main advantage of this system is the absence of dead-water areas in any part of the channel, because water is able to flow through the spaces between the vertical bamboos. This absence of dead-water areas, ensures prevention of formation of eddies.

The slightly increased velocity, between the rows of "bandals" LL and RR, enables a current of water to scour the river bed and deepen the channel, while the slightly decreased velocity over the other parts of the channel, causes deposit of silt and rise of river bed. The decrease of discharge over the shallower parts of the channel, further increased the discharge between the rows of "bandals" L L and R R, so that there is further downscouring and deepening of the channel. Navigation depth is thus maintained in the reach DE of the river.

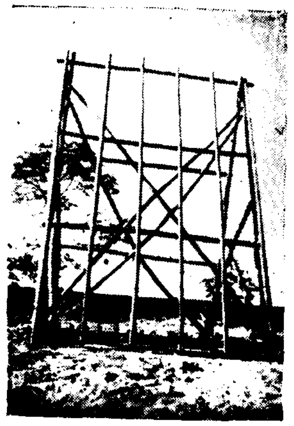
IMPROVED TYPE OF "BANDAL"

With continuous deepening, the vertical bamboos, which are driven 3 or 4 feet in the river bed, are undermined and they topple over. But by this time, the flood season starts, increasing the depth of water, inthe channel so that "bandals" are no longer necessary and are removed.

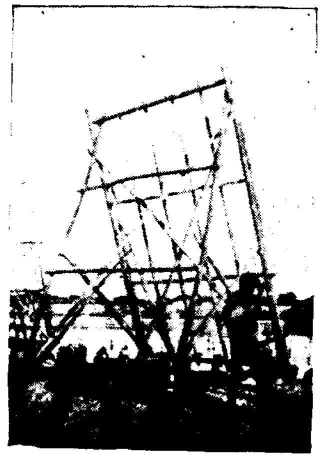
To ensure that the force of the current of water in a river is utilised, not only in the dry season but also in the flood season, an improved type of "bandal" was developed by the author. The Beki River in Assam formed an embayment *ADEC*, by erosion of its right bank, which became 3000 feet long, with a maximum width of 1000 feet, and a maximum dry season depth of 40 feet Fig. 5. This embayment caused oblique flow through the bridge, thereby threatening undermining of the bridge piers. The Railway Administration decided to straighten the river alignment upstream of the bridge. The author, under whose supervision this work was done, laid improved type of "bandals" along the line ABC, across the embayment.

Each unit of improved "bandal" as shown in Fig. 6, is a prismoidal structure 10 feet long, having isosceles triangle ends, the width of base varying from 8 to 12 feet, and the height varying from 12 to 20 feet. Stout bamboos were used, 1/4 inch mild steel rods being used for fastening at the joints. On the river side face, 6 vertical bamboos acted as "bandals",

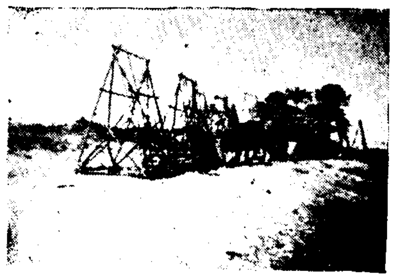
IMPROVED TYPE OF "BANDALS" IN THE BEKI RIVER, ASSAM.



FRONT VIEW OF AN UNIT OF IMPROVED "BANDAL."



SIDE VIEW OF AN UNIT OF IMPROVED "BANDAL"



UNITS OF IMPROVED "BANDAL" FABRICATED ON BEKI RIVER BANK.

UNITS OF IMPROVED "BANDAL" LAID ON BEKI RIVER BED.

NEW RIVER BANK FORMED BY A LINE OF IMPROVED "BANDALS."

Fig. 6.

units of improved types of "bandals" were fabricated on the river bank, carried on a boat to the site along *A B C*, where a floating derrick lifted it up, four weights each weighing ¼ ton were tied to the four bottom corners of the framework, and the unit was lowered on to the river bed and accurately aligned along the line A B C. Adjacent units were tied to each other by stout mild steel wires, while a wire cable was tied to the tops of all the units, the ends of the cable being anchored in the river bank. Such tying is essential, in order that the "bandals" are maintained in a good alignment. On such alignment, ensuring smooth flow depends the action of the "bandals".

The Table below gives velocities on either side of the line of "bandals", in the river, in different months :

happened over the whole of this area, which was reclaimed to form a new right river Bank on a straight alignment along ABC. The slightly increased velocity on the river side of the line of "bandals", deepened the channel and eroded the projecting left river bank FGH, which became more or less parallel with the line ABC.

The wide base of the improved type of "bandals", gives it a stable bearing on the river bed, while the four weights at the four corners enables each unit to remain steady, even in a current of water with a high velocity. There is thus no toppling over, as happens with the deepening of channel in ordinary "bandals".

Instead of bamboos, wooden bullahs or timber scantlings can be used for the

Date	Velocity in the Beki River on either side of the line A B C—ft per second.		
	Embayment Side	River Side	Remarks
15-1-49	1.6	13.19	Dry Season
16-2-49	0.95	2.90	,, ,,
16-3-49	2.15	3.73	,, ,,
17-4-49	2.21	3.91	,, ,,
22-5-49	4.44	5.58	Flood Season
17-6-49	5.92	6.33	,, ,,
17-7-49	5.32	8.35	,, ,,
16-8-49	9.56	11.10	,, ,,
24-9-49	4.25	4.72	,, ,,
17-10-49	2.99	3.32	Dry Season

A study of the Table shows that the line of "bandals" A B C caused only slight difference in the velocity in the river on the embayment and river side of the line. But as the power of transportation of silt of a current of water varies between 3.2th to the 6th power of the variation in velocity, this slight decrease in velocity caused a current of water to deposit a considerable part of its silt load on the embayment side of the line of "bandals". As there was no dead-water area in the embayment, the silt deposit

fabrication of structures of the improved type of "bandals". The cost varies from about Rs 20 to Rs 40 per running foot, depending on the depth of water in the channel and on the type of river.

A CHALLENGE TO ENGINEERS

The rivers crossing the Assam Access Road and the Assam Rail Link, are now a Challenge to engineers. Not only enormous amounts of money have

(*Continued on page 29*)