The Chairman was in accord with popular opinion, that in the long run a steel bridge was cheaper than a timber structure, but the Author pointed out that this popular opinion only held good when pine or other soft wood with a short life was used, in lieu of the much more durable Australian hardwood, and that the Chairman did not support his opinion with the necessary tabulated statement, similar to that submitted by the Author, shewing the comparative cost of interest, renewals, and maintenance of a steel and timber structure. As previously reasoned, Mr. Allan considered it would have been incorrect to compare the Wagga Wagga timber bridge with an iron bridge based on imported prices, but even supposing it possible that by importing the iron bridge the cost could have been reduced by £1,000, there would still be a saving of £10 per annum in annual charge, equal to a capital value at 4% of £250 per span in favour of the timber structure. As the decks in each bridge were similar, the inconvenience to traffic during renewals would be common to both designs, whilst the timber truss members could at the end of twenty-five years (if then decayed) be renewed without interrupting traffic.

FASCINE WORK AS CARRIED OUT BY THE PUBLIC WORKS DEPARTMENT IN NEW SOUTH WALES.

By T. E. Burrows, L.S.

(Communicated by J. W. Grimshaw, M. Inst. C.E.)

[With Plates 9, 10.]

[Read before the Engineering Section of the Royal Society of N. S. Wales, October 15, 1895.]

The history of embankments for river training purposes in New South Wales, in which the use of fascines of Ti-tree, or similar scrub form part, commenced as far as the author is aware only
ten years back; but the principle of using fascines of a bushy nature, to bind clay or soil together, has been availed of in many and various instances, either for rough mining dams, or to form mattrasses upon which roads or light tram lines might be carried across swampy ground.

Indeed the first fascine work with which the author was connected, was the construction of a temporary dam of fascines and untempered clay, at a breakaway in the town dam (on western end) at Parramatta about 1880; and owing to the force of the water, the river being in flood at the time, it can safely be asserted that only through the use of fascines, for binding the clay, and easing off the power of the stream, the work of repair to the main dam would have been much more expensive than was actually the case.

Fascine work was introduced when Mr. E. O. Moriarty was head of the Harbours and Rivers Department, but the greater portion was carried out under the Engineer-in-Chief, Mr. C. W. Darley.

The credit of the introduction of this class of work into New South Wales is due to Mr. Alfred Williams, M.Inst.C.E., under whom the author had considerable experience, and as Mr. Williams had the advantage of employing this description of river bank protection in England, at the river Severn; where the range of tide is considerably more than our six feet, he saw to what advantage such work could be put, in the proper alignment of our rivers with their unsightly, useless, and muddy Mangrove flats; where the use of stone embankments would prove too costly to allow of the work being undertaken; especially in such places were soft bottoms are met with, as the entrance to the Long Cove Canal at Leichhardt.

Two notable descriptions of fascine work, have been constructed under the supervision of officers in the Public Works Department, and these the author will designate as "Fascine Embankments" and "Fascine Wall."
Fascine Embankments.

The embankment work has been carried out in the following localities, and an approximate statement of the extent of each is also given—

**District of Sydney.**

<table>
<thead>
<tr>
<th>Locality</th>
<th>Length</th>
<th>Width average</th>
<th>Height average</th>
<th>Purpose</th>
<th>Area reclaimed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cook’s River</td>
<td>520 chains</td>
<td>14 feet</td>
<td>9 feet</td>
<td>reclamation</td>
<td>413 acres</td>
</tr>
<tr>
<td>Shea’s Creek¹</td>
<td>130 &quot;</td>
<td>14 &quot;</td>
<td>9 &quot;</td>
<td>do. &amp; canal</td>
<td></td>
</tr>
<tr>
<td>Muddy Creek</td>
<td>125 &quot;</td>
<td>14 &quot;</td>
<td>9 &quot;</td>
<td>do.</td>
<td></td>
</tr>
<tr>
<td>Leichhardt</td>
<td>153 &quot;</td>
<td>12 &quot;</td>
<td>9 &quot;</td>
<td>reclamation</td>
<td>81 acres</td>
</tr>
<tr>
<td>Callan Park</td>
<td>12 &quot;</td>
<td>12 &quot;</td>
<td>9 &quot;</td>
<td></td>
<td>5 &quot;</td>
</tr>
<tr>
<td>Homebush Bay</td>
<td>210 &quot;</td>
<td>12 &quot;</td>
<td>9 &quot;</td>
<td></td>
<td>201 &quot;</td>
</tr>
<tr>
<td>Duck River</td>
<td>18 &quot;</td>
<td>12 &quot;</td>
<td>9 &quot;</td>
<td></td>
<td>41 &quot;</td>
</tr>
<tr>
<td>Tarban Creek</td>
<td>16 &quot;</td>
<td>12 &quot;</td>
<td>9 &quot;</td>
<td></td>
<td>7½ &quot;</td>
</tr>
</tbody>
</table>

**Newcastle District.**

<table>
<thead>
<tr>
<th>Length</th>
<th>Width.</th>
<th>Height.</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horseshoe Bend</td>
<td>13 chains</td>
<td>50 feet</td>
<td>30 feet; protection of river bank</td>
</tr>
<tr>
<td>Belmore Bridge</td>
<td>17 &quot;</td>
<td>20 &quot;</td>
<td>30 &quot;</td>
</tr>
</tbody>
</table>

**Hawkesbury District.**

| Sackville Reach | 1 chain | 8 x 16 feet | |

**Grafton District.**

Public School, 7 chains, 10 x 12 feet, protection of river bank.

Great Marlow Embankment, 60 chains of combination bank, part earthwork only; protection of river bank,

**Moruya District.**

Moruya River, left incomplete and damaged by floods, length 58 chains, by 14 feet by 9 feet; for training wall purposes.

Of the larger works two may be practically called complete, that at Iron Cove, Callan Park, and also the one at Long Cove; the areas between original high water mark and the present sea face of the embankments, having in each case been filled in to a height of three feet above high water mark by the sand-pumps "Groper" and "Neptune."

¹ Shea’s Creek refers only to original creek affected by tidal waters.
The embankment on the western side of the Long Cove Canal has been one of the most difficult of any of these works to deal with, owing to the soft bottom met with in places, which in no case developed when the bank was being constructed, but when the filling was being placed behind.

The weight of filling being greater than the weight of an equal bulk of bank, pressed the soft mud out from beneath the bank into the canal. Section herewith showing the fascine work only slightly disturbed, yet a considerable cavity at back with a corresponding rise in front.

To curb this subsidence of the filling, piling along the toe of the bank has been resorted to, and only one subsidence has since been reported, which is attributable to the piles being of insufficient length to reach beyond the liquid mud underlying the bank, although twenty-six feet long.

In one instance at the mouth of the canal, ballast was tried, but after 3,500 tons of stone had been deposited over an area of 444 square yards, the ballast was still sinking, at the same time displacing the mud as shown by an upheaval in the canal near by.

The following is a detailed description of the method of construction of fascine embankment; after the alignment has been done, and the author can state from severe personal experience, that the setting out of the work is no trifle, when over your knees in mud and still sinking, you are uncertain whether to tell the chainman to come and pull you out, or go on with his distances.

A trench 18 feet wide is made to a depth of 1 foot below low water mark, spring tides, and then the first layer of fascine is laid for a length of about 50 feet with the bushy ends out, bearing in mind that the next layer has to bond over them. A layer of mud 9" to 1' deep is then deposited on the fascines, and the work carried up in a similar manner until the requisite height is reached, attention being given to breaking bond with the fascines, by using long or short bundles as required.
A shrinkage of the fascines usually takes place under the weight of the mud, and during the first twelve months amounts to 12" or 18", and this shrinkage is made up with silt or other good surface material obtainable.

The first cost of fascine embankment work—at the section given—is under 3/- per cubic yard, inclusive of backing with silt for an average width of 3'; and when the fact that such small subsidence has to be allowed for, and a very small expenditure for maintenance, the embankment may be considered a cheap training wall with a life of over twenty years. Some of this work constructed at Cook's River, nearly ten years ago, bearing out the probability of this statement.

When a scour occurs or the proximity to a steamer's wash is unavoidable, it has been found advisable to face the embankment with fascines, as shown in Section "A"; that is, with a liner or stretcher fascine staked down along the face of each layer of silt.

Embarkment work of this nature, has been considered as specially liable to damage from fire; but the experience of the author is against this theory, and where the bank has a good top layer of mud, and the fascines are kept to high water spring tides level, it is almost impossible to seriously damage the work by fire. Timber shoots or box drains are used to relieve the banks while in their early stages, from the water pressure caused by falling tides: the shoots being fitted with a hinged flap, which opens outward only; and where large areas are dealt with, or considerable back water has to be released, a self-acting sluice door is used for the same purpose.

In concluding the remarks on embankment work it may be mentioned that where the banks have been constructed by trucking the material for the work ahead, over that recently constructed behind, greater consolidation and security are gained at a very slight additional cost. The Great Marlow Embankment was a combination of earthwork with a fascine face, where height of bank exceeded 5' and was constructed for protection of river banks from erosion (section herewith).
FASCINE WORK IN N.S.W.

Fascine Wall Work.

This class of work differs materially from that already described, as this is a thin wall or fence which acts the part of a screen, preventing the silt or similar material deposited at the back of same in a liquified condition, from obtaining access again to the river channel. This work has been constructed at the Myall River, and was carried out by Mr. H. D. Walsh, M. Inst. C.E., under Mr. Darley's instructions, and has been very successful.

It is formed by driving a row of piles, from 6" to 8" diameter—of either turpentine or ti-tree with the bark left on—batttered slightly inwards, and 3' apart, and driven 8' or 10' into the ground. By using a 12" x 12" ironbark ram and steam driving plant on punt, as many as 50 piles could be driven per day, but the author may here remark that where sand is met with, by using a steam pump the piles could be put in much faster and more batter given if required.

Continuous ropes were then formed of pliable ti-tree—from 10' to 15' bushes—and as the rope was formed on the punt, it was bound by 14 gauge wire every 18", and then woven between the piles, and well pressed into place.

It was found necessary to place a small bank of stones, shells, or other suitable material, outside of this fence, to keep out the "Teredo," which are very plentiful in this river.

Plan and sections herewith marked, "B."

Discussion.

Mr. Darley, said, there was nothing very novel about the use of fascine work; it was a very old class of work, but had only been introduced into this Colony during the last ten years; it had been used for enclosing reclamations, training banks, and strengthening river banks, for which latter work it had proved exceedingly satisfactory. The banks of the Mississippi River are protected by endless fascine mattrasses of about 20 ft. wide, laid on the surface, and then loaded with stone. Experience here

3—Sept. 18, 1895.
proved to him that it would be worse than useless to use fascine for training banks of channels again. The work at Moruya was an utter failure, the fascines were laid on a sand bottom, and when the very first flood took place the sand scoured away and the whole bank floated out to sea, this was anticipated by the then Engineer-in-Chief, Mr. Moriarty, who reported strongly against the use of fascine for such a purpose. The work of this class at Long Cove has not been the success it might have been, piles had lately been driven in, and he believed that they are being pressed forward. He thought that in many cases it would have been cheaper, and more economical to carry out the work with stone, for when the water in front deepens, the stone will run down and check the scour; this is very noticeable at Newcastle, where there is a dyke of a mile and a half in length. This dyke was laid out by the speaker, the construction being commenced at low water, there is now over twenty feet of water close beside it. The stone does not sink with the sand, but as the scour takes place the stone runs down off the face of the dyke and so checks further erosion, and it is a simple matter to make good the loose stone again till the full depth is reached. In this country where in the majority of cases, our coastal harbours have sandy bottoms, fascine work would be quite useless. In the case of some rivers, say the Hunter, some excellent work has been done with fascines, and it has been found a very effective protection against flood, but there it is made of layers of fascine and stone, loaded and coated with stone.

Mr. Deane, said the first cost of work was put down as being under three shillings per cubic yard, but he was under the impression that the work cost a great deal more, and he would like to know from Mr. Darley, where fascine work came cheaper than stone.

Mr. Darley said in reply to Mr. Deane's question, "in what way fascine work came cheaper than stone"? that stone would be very costly to make large dykes of. In our river banks the introduction of the fascine and stones proved itself very effective, where you
have stone only it is very apt to slip forward, owing to excessive weight on the toe when a scour takes place in the river. A mixture of fascine, clay, and stone will stand a heavy rush of water, and has proved to be very successful, it is light, and does not put too much weight on the toe of the bank, that is speaking of a bank of forty to fifty feet in height, alternate layers of stone and fascines have proved very successful. When commencing work at the Tweed River, great pressure was brought to bear to have fascine work introduced, this was not done, as he pointed out what must happen if this class of work were adopted, it would be sure to scour away. It ended that he carried out the work cheaper than any work of a similar kind in the Colony, certainly everything was favourable to this end, and it is now a permanent, lasting, and cheap work. Formerly there were ten to twelve inches of water, but now there is a depth of over fourteen feet, and in cases of that sort stone is the proper thing to use. In cases like Cook's River where stone is scarce and would have been very costly, fascine work was suitable, but if the channel is to be deepened eventually the banks must be faced with stone to make them permanent.

Mr. Grimshaw agreed with Mr. Darley's remarks, but did not consider that the author had written the paper with any view of making a comparison between stone and fascine work, or misleading anyone in believing that facine work was superior to stone, but simply with a view of describing where and how fascine work was being used by the Public Works Department of this Colony. Some of the failures mentioned were attributable to the fact that fascine is used on mud flats, or where the bottom is very soft and difficult to deal with. He had no doubt whatever, that for a first class work stone should be used, but in many cases it was quite out of the question on account of the expense, although stone ballast is much cheaper now than it was. Most of the fascine banks had stood very well indeed, though in places where washed by the salt water they could not get any protection from vegetation, which forms a great protection
in fresh water. The slips described by the author have given a great deal of trouble, the slip at Long Cove occurred in spite of piles having been driven twenty feet into the mud, they invariably occurred when the dredges were filling in at the back of the bank, and at low tide. It was the weight at the back of the bank that pushed the mud through and underneath the bank, and the same occurred in a lesser degree in stone dykes. In the case of the Moruya work, mud and silt in the ends of the fascine dyke were washed away by sea waves, leaving the bushes only; and no doubt stone should have been used. Still in his opinion the work was started from the wrong end, it should have been commenced at the shore or upstream end, instead of which it was commenced at the sea end. When the flood came down the river it got at the back of the dyke and washed a great portion of it away. In swampy country, such as Cook’s River, an immense amount of stone would have been absorbed as there is no saying to what depth it would have sunk in the soft mud. In the case of Rozelle Bay it sank over eight feet, and in Long Cove it disappeared altogether. There was no more expense in keeping the fascine work in good order than was experienced with the sides of an ordinary river, when once the reclamation was complete. He was quite of opinion that the facing of fascine banks should be of stone, if possible, and where there was a rocky or hard bottom stone should be used entirely.

Mr. P. Allan said, where you have to dredge a channel to a considerable depth, it is inadvisable to use anything but stone, as he believed it to be very doubtful whether successful work could otherwise be done.

Mr. Simpson said that he quite agreed with the remark that more is sometimes to be learned from failure than from success, but as it has been pointed out by members there are cases in which fascine work would be quite inappropriate, and in other cases fascine work should undoubtedly be adopted.

Mr. Burrows in reply, stated, that the primary reason of this paper was to give information, as to the purposes for which fascine
work is used in New South Wales, and not for any comparison with stone embankments. For if stone can be used, from an economical point of view it should be. In the case of Long Cove, at one point stone was used with no success, as it was found that the stones kept sinking. Piles were afterwards used, and were put down to a depth of forty-seven feet, the last strata was softer than the upper crust, so that the building of a stone dyke at a one to one slope section, would cost infinitely more than the fascine work. The slips occurred through using the bank as a dam, a purpose for which it was never intended, large lakes of water were formed behind them by the use of sand pumps. This water would have at least a six feet head at low tide. Mr. Grimshaw pointed out in the case of the Moruya work, and he agreed with him, that it was started at the wrong place, and that it had not only the ordinary run of the tide but when a flood came there was nothing to protect it from the scour, consequently the water got both back and front of it, and gave it no chance whatever. The dykes of Holland are constructed largely of mud, and only faced with mattrasses of something similar in character to ti-tree; weighted with stone or rip-rap, certainly they have much flatter slopes, which are necessary on account of their abutting on the open sea. An instance of the cost of stone in a finished dyke is Rozelle Bay, this is six feet wide on top, with a one to one slope on both sides, the bottom is fairly soft, the stone used was tipped over the ends of the bank, and the cost of stone here compared to fascine work, allowing for a subsidence of the latter of three feet, would be about two to one. He found that the stones had displaced the silt to a depth of from something like ten to fifteen feet, the average being eleven feet for a length of 1,650 feet of dyke. Fascines sometimes give a very ragged appearance to a bank, and the cost of facing up is about fifteen shillings per rod, but when a bank will stand about five years without having anything done to it, this extra payment for maintenance is very inconsiderable. The percentage of shrinkage is about 15\% on the section of the bank during the first twelve months.

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