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MADRAS RECORD OFFICE.

Government of Madras.

Public Works DEPARTMENT.

G.O. No. 2253 Press Mis.

Dated 3 - 72 18 72

Not to be folded or roughly handled

No. 92. Read the following letter from Colonel C. E. FABER, Chief Engineer; to H. FORBES, Esq., Acting Secretary to Government, dated 18th November 1857, No. 5293.

SIR,

I have the honor to forward for the consideration and orders of Government copies of a letter from Colonel A. T. Cotton, Commandant of Engineers, under date the 20th Ultimo, and of its enclosure, a Memorandum on the present state of our knowledge of the construction of River boats and recommending that, the experiments lately made at the Godavery which have led to new light being thrown on the subject, may be continued, in order that the results then obtained may be carefully tested, and sound principles established by a series of more complete and decisive experiments.

1 Copy of a letter from Colonel Cotton No. 514 dated 20th October 1857.
1 Memo from Do. of the same date.

2. Colonel Cotton shews that, while attention has been chiefly paid to the forms of the bow and stern and to the midship displacement of vessels, there has been overlooked entirely the retarding effects of surface friction which would appear to influence the attainment of speed in so great a degree as to vitiate all calculations, when its effect is not taken into full account, for, with the speed of 2½ miles an hour the resistance of a common coppered surface was found to be $\frac{1}{60}$th of a lb. per square foot, and that of a surface of painted wood or iron $\frac{1}{15}$th of a lb. or four times as much. It naturally follows, that a highly smooth metallic surface such as experiments might lead to the adoption of, would reduce this element of resistance to such a point as materially to affect all calculations, and Colonel Cotton therefore strongly urges the importance of continuing the investigation, in order to establish the soundest practical formula for the guidance of those who may be called upon to provide boats for the rapidly developing river and Canal navigation of this country.

3. Colonel Cotton recommends for the purpose, a series of experiments, having for their object the determination.

1st. Of the resistance due to displacement of a simple form of midship section which he describes, but with different Angles of the bow or entrance, and

2ndly The resistance due to the friction of various surfaces of which he enumerates the following.

I. Plain wood newly immersed.
II. Do. with the matter that forms on it after a time.
III. Wood highly polished.
IV. Do. with different kinds of paint wood.
V. Wood covered with Zinc.
VI. do. Coppered.
VII. do. with Muntz metal.
VIII. do. metalled with extraordinary care and as smooth as possible, without nail-heads &c.
IX. Painted Iron.

4. I quite concur with Colonel Cotton in his views of increasing importance of this subject, but I am compelled to differ from him as to Madras being a fit place for the experiments, or the Central office the proper Agency for conducting them. In the first place if they be undertaken here, they must be made on small models, which give results very different to those obtained on the full scale, and lead to fallacious conclusions which detract effectually from the practical value of the experiment, and in the second place, the attention of the Central office cannot be given, with effect, to executive operations such as these experiments involve, nor can the time of its members be spared without impeding the despatch of its legitimate business.

5. I would prefer the experiments being continued where they were begun, and as a Naval Officer, with Mechanical attainments of a high order, has been nominated to the Godavery Division, Dowlaishweram would appear to be the fittest locality, and Captain Rundall, assisted by Lieutenant May, the proper Agent for carrying them on. On the other hand Rupees (500) five

hundred, at which Colonel Cotton estimates the cost will not go far in experimenting on the full scale, but being averse to recommend any larger outlay, I leave the question in the hands of Government.

Letter from Colonel A. COTTON, Commandant of Engineers; to Colonel C. E. FABER, Chief Engineer, dated 20th October 1857, No. 514.

SIR,

We have made so much progress of late in our knowledge of the subject of resistance of boats, that it seems to me advisable to put on paper the state of the question at present, and to make a set of experiments such as our late experience suggests. I have therefore the honor to to offer to you a short Memorandum containing only the *results* of our trials so far, and suggesting further experiments. I feel satisfied that, we have now got a true clue to the subject, and that a few very simple experiments will therefore produce great results, should you agree with me in this view of the subject, I would suggest that, application should be made to Government for authority to make these experiments.

Memorandum on River Boats.

The late experiments with boats on the Godavery have led to the following conclusions, some of which require to be tested by more complete and decisive experiments.

1st. That the form which gives the least possible draft, that is, with a perfectly flat bottom fine and aft, is a thoroughly effective form, as respects management, and is also quite compatible with an extremely small resistance.

2nd. That with a fine entrance, or in other words, very sharp bows and corresponding run or stern, the greater part of the resistance by far is the friction on the surface; and the resistance of displacement of water is much less.

3rd. The resistance of friction on a common coppered surface seems to be about $\frac{1}{30}$ lb ℔ square foot at the standard speed of $2\frac{1}{2}$ miles an hour.

4th. The surface resistance on painted wood, or Iron, is about $\frac{1}{15}$ lb ℔ square foot, or four times as great as that on an ordinary metal surface.

5th. The resistance to a square foot of surface moving through the water at $2\frac{1}{2}$ miles an hour, in a line perpendicular to itself, is theoretically 13 lbs.

6th. The resistance of a square foot of the greatest immersed section of a boat is diminished, as the square of the length of the entrance to that of the half breadth. That is, if the bow of a boat is 6 times the breadth, the resistance of displacement ℔ square foot of section is to that of a flat surface, as $1 : 12^2$ or as 1 to 144, and consequently $\frac{1}{7}$ lb at $2\frac{1}{2}$ miles.

So far as our experiments went, they seemed to prove that, resistances were an approximation to these proportions. Thus when the new Iron Steamer was building, her resistance was calculated upon these principles, and her speed compared with the actual power of steam, agrees very well with the calculation. Still the experiments were so few and so roughly made, that they were very far from conclusive.

Thus far however seems certain that, all former recorded experiments on boats are of little value, because they did not distinguish the principal item of resistance, the surface friction giving all results in one item, viz, resistance ℔ square foot of section, what is now wanted therefore is, a set of careful experiments, 1st distinguishing surface from displacement resistance, and 2nd trying various means of reducing the latter.

Thus an entirely new field is opened out. Hitherto attention has been almost entirely confined to a comparatively insignificant part of the subject, and the real main obstacle has been scarcely thought of.

It is impossible to say, what may be accomplished when attention is turned to the really important portion of the resistance.

Fort Saint George, Public Works Consultation of 8th December 1857.

As one proof of the effect of attention to surface, I may mention that, a boat was taken just in the state it was ordinarily used, and by improving the surface, without altering the form, the resistance was reduced to $\frac{1}{3}$rd of what it was before.

Of the results of the new form as respects draft of water, I may mention, that a heavily built teak boat, square feet 90×10, draws light 6 inches, and carries 20 tons ℔ foot of draft, so that, she can carry 10 tons in 1 foot of water, and the new Steamer of Iron, 114 feet $\times 14\frac{1}{2}$, with a 25 H. Engine on board draws 12 inches, without fuel, and has gone 9 miles, she will probably go 10 or 11, when she has been worked a little more. She could tow at 5 miles an hour, 20 or 30 boats, of the dimensions of the one first mentioned, carrying 10 tons each, thus conveying 2 or 300 tons in 1 foot water at 5 miles.

We have thus positive proof that, a river can be worked effectually with 1 foot depth of water; and with such boats built lighter, and loaded with 6 tons, with 9 inches of water.

The form given to these boats, is a perfectly flat bottom, with wall sides fore and aft, and the lines those of Mr. Scott Russel. This form, besides the advantages of small draft and small resistance, is much cheaper than any ordinary form of boat. The ribs are all straight pieces, and the planks have very little bend in them, so that there are none of the ordinary difficulties of boat building in them. It's all plain Carpenter's work, and there is no waste of timber.

What seems to be now wanted is, a careful set of experiments on models, to ascertain exactly.

1st. The resistance due to displacement, with this form, but with different angles of entrance.

2nd. The resistance due to friction.

on 1st Plain wood newly immersed.

2nd. Do. with the matter that forms on it in the water after a time.

3rd. Wood, highly polished.

4th. Do. with different kinds of paint, varnish, &c.

5th. Wood zinced.

6th. Do. covered in the usual manner.

7th. With Muntz metal.

8th. Wood metalled with extraordinary care so as to give a far more smooth surface than usual, clear of nail heads, indentations, &c.

9th. Painted Iron, &c. &c.

For this purpose, I should recommend a wooden trough about 40 feet long, and a little apparatus to allow of a line passing over pulleys, with a weight attached, so as to draw the models by the force of gravity. Such an apparatus would be very little expense. This set of experiments will save a very great expense in trials with boats of the full size. A Superior Warrant, or Non-Commissioned Officer, might be put in charge, and the whole superintended by Lieutenant O'Connell.

I should think 500 Rupees would be sufficient to provide for such a set of experiments as is here contemplated.

I beg to notice, how vastly important a subject this is now becoming, and how urgent it is that the Officers of the Public Works Department should be provided with some clear and sound principles on the resistance of Canal and River boats, before water transit is much more extended. Had we known when we began the Godavery works, even as much as we do now about the boats; it would have saved us an extraordinary amount of money and time.

I may also add that, at this time, a very great prospect of improvement in boilers and engines for boats is opening out in England, so that between that and clearer notions about the resistance of boats, there is every prospect of obtaining very high speeds if required, with 1 foot draft a speed of 20 miles an hour for instance.

Fort Saint George, Public Works Consultation of 8th December 1857.

No. 93. ORDER THEREON, No. 2283; dated 8th December 1857.

The Right Honorable the Governor in Council authorizes the sum of Rupees (500) five hundred, being placed at the disposal of Colonel A. T. Cotton, Commandant of Engineers, for continuing the experiments lately made at the Godavery on the surface friction of boats. Colonel Cotton will be at liberty to make his own arrangements for carrying out the above experiments.

(Signed) H. FORBES,
Acting Secretary to Government.

Comdt. of Engineers Office
No. 574

From The Commandant of Engineers
To The Chief Engineers
D. P. W.
Fort St. George

Sir,

We have made so much progress of late in our knowledge of the subject of Resistance of Boats, that it seems to me advisable to put on paper the state of the question at present, and to make a set of experiments such as our later experience suggests. I have therefore the honor to offer to you a short Memorandum containing only the results of our trials so far, and suggesting further experiments. I feel satisfied that we have now got a true clue to the subject, and that a few very simple experiments will therefore produce great results. Should you agree with me in this view of the subject, I would suggest that application should be made to Government for authority to make these experiments.

I have &c
(Sd.) A. Cotton Colonel
Commandant Engineers

Memo:

Memorandum on River Boats.

The late experiments with boats on the Godavery have led to the following Conclusions, some of which require to be tested by more complete and decisive experiments.-

1st That that form which gives the least possible draft, that is, with no perfectly flat bottom fore and aft, is a thoroughly effective form, as respects management, and is also quite compatible with the extremely small resistances.-

2nd That with a fine entrance, or in other words, very sharp bows and corresponding run or stern, the greater part of the resistance by far is the friction on the surface, and the resistance of displacement of water is much less.-

3rd.- The resistance of friction on a common copper surface seems to be about 1/10 lb per square foot at the standard speed of 2½ miles an hour.-

4: The surface resistance on painted wood, or Iron, is about 1/5 lb per square foot, or four times as great as that on an ordinary metal surface.-

5: The resistance to a square foot of surface moving through the water at 2½ miles an hour, in a line perpendicular to itself, is theoretically 13 lbs.-

6: The resistance of a square foot of the

greatest immersed section of a boat is diminished, as the square of the length of the entrance is to that of the half breadth. That is, if the bow of a boat is 6 times the breadth, the resistance of displacement per square foot of section is to that of a flat surface, as 1: 12² or as 1 to 144, and consequently 1/11 lb at 2½ miles.-

So far as our experiments went, they seemed to prove that resistances were an approximation to these proportions. When the new Iron Steamer was building, her resistance was calculated upon these principles, and her speed compared with the actual power of steam, agrees very well with the calculation. Still the experiments were so few and so roughly made, that they were very far from conclusive.

Thus far however seems certain that all former recorded experiments on boats are of little value, because they did not distinguish the principal item of resistance, the surface friction giving all results in one item, viz, Resistance per Square foot of section. What is now wanted therefore is, a set of careful experiments. 1st distinguishing surface from displacement resistance, and 2d trying various means of reducing the latter.-

Thus an entirely new field is opened out. Hitherto attention has been almost entirely confined to a comparatively insignificant

insignificant part of the subject, and the real main obstacle has been scarcely thought of.

It is impossible to say what may be accomplished when attention is turned to the really important portion of the resistance.

As one proof of the effect of attention to surface, I may mention that a boat was taken just in the state it was ordinarily used, and by improving the surface, without altering the form, the resistance was reduced to 3/4 of what it was before.

Of the results of the new form as regards draft of water, I may mention, that a heavily built boat 60 x 10, drawing 18 inches, and carrying 22 tons per foot of draft, so that she can carry 10 tons in 1 foot of water, and the new Steamer of Iron, 114 ft x 14 ft, with a 25 H. Engines on board draws 13 inches without fuel, and has gone 9 miles, she will probably go 11 or 11, when she has been worked a little more. She could tow at 5 miles an hour, 20 or 30 boats, of the dimensions of the one first mentioned, carrying 10 tons each, thus conveying 200 or 300 tons in 1 foot water at 5 miles.

We have thus four lines of

proof that a river can be worked effectively with 1 foot draft of water, and with such boats built, lighter, and loaded with 6 tons with 9 inches of water.

The form given to these boats, is as perfectly flat bottom, with wall sides fore and aft, and the lines those of the Bell Punt. This form, besides the advantages of small draft and small resistance, is much cheaper than any ordinary form of boat. The ribs are all straight pieces, and the planks have very little bend in them, so that there are none of the ordinary difficulties of boat building in them. It's all plain Carpenters work, and there is no waste of timber.

What seems to be now wanted is, a careful set of experiments on models, to ascertain exactly —

1st The resistance due to displacement, with this form, but with different angles of entrance.

2d. The resistance due to friction on 1st Plain wood newly immersed

2d - Do. with the matter that forms on it in the water after a time

3d Wood highly polished

4th - Do. with different kinds of paint, Varnish &c.

5th Wood grained

6th - Do. covered in the usual manner

7th With

7th Wrought Metal.

8th Wood metalled with extraordinary Care, so as to give a far more smooth surface than usual, clear of Nail heads, indentations &c.

9th Painted Iron

8th 9th

For this purpose, I should recommend a wooden trough about 18 feet long, and a little apparatus to allow of a line passing over pulleys, with a weight attached, so as to draw the models by the force of gravity. Such an apparatus would be very little expense. The cost of experiments will seldom exceed expenses in trials with boats of the full size. A Superior Warrant, or Non-Commissioned Officer might be put in charge, and the whole superintended by Lieutenant Powell.

I should think 500 Rupees would be sufficient to provide for such a set of experiments as is here contemplated.

I beg to notice, how wastly important a subject this is now becoming, and how urgent it is that the Officers of the Public Works Department should be provided with some clear and sound principles on the resistance of Canal

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and River boats, before water transit is much more extended. Had we known when we began the Railways, even as much as we do now about boats, it would have saved us an extraordinary amount of money and time.

I may also add that, at this time, a very great prospect of improvement in Boilers and Engines for boats is opening out in England, so that between that and clearer notions about the resistance of boats, there is every prospect of obtaining very high speeds if required with 1 foot draught, a speed of 20 miles an hour for instance.

(and) Lt Colonel
Engrs
Dec 8 October 1839

Comdt of Engrs Office
Lt Colonel
Comdt of Engineers

True Copies

Lieutenant Colonel
Chief Engineer

(2)

Central Office of P. W.
No. 5293. Pah. St George 18 November 1857.

From The Chief Engineer
To The Secretary to Government
P. W. Department

"Public"
Boats.

Sir I have the honor to forward for the consideration and orders of Government copies of a letter from Colonel A. S. Cotton, Commandant of Engineers, under date the 20 Ultimo, and of its enclosure, a Memorandum on the present state of our knowledge of the construction of River Boats, and recommending that the experiments lately made at the Lodaverry which have led to new light being thrown on the subject, may be continued; in order that the results then obtained may be carefully tested, and sound principles established by a series of more complete and decisive experiments.

2. Colonel Cotton shows that, while attention has been chiefly paid to the forms of the bow and stern, and to the midship displacement of vessels, there has been overlooked entirely the retarding effects of surface friction, which would appear to influence the attainment of speed in so great a degree as to vitiate all calculations, when its effect is not

taken

taken into full account, for, with the speed of 2½ miles an hour, the resistance of a common coppered surface was found to be 1/60" of a lb per square foot, and that of a surface of painted wood or iron 1/15 of a lb. or four times as much.. It naturally follows that a highly smooth metallic surface, such as experiments might lead to the adoption of, would reduce this element of resistance to such a point as materially to affect all calculations, and Colonel Cotton therefore strongly urges the importance of continuing the investigation, in order to establish the soundest practical formula for the guidance of those who may be called upon to provide boats for the rapidly developing River and Canal Navigation of this Country..

3. Colonel Cotton recommends for the purpose, a series of experiments, having for their object the determination.

1st of the resistance due to displacement of a simple form of midship section which he describes, but with different Angles of the bow or entrance, and

2d. The resistance due to the friction of various surfaces, of which he enumerates the following..

I. Plain wood newly immersed..
II. - Do. - with the matter that forms on it after a time..
III. Wood highly polished..
IV. - Do. - with different kinds of paint

Wood

V. Wood covered with Zinc.
VI. - Do. - Coppered.
VII. - Do. - with Muntzmetal.
VIII. - Do. - metalled with extraordinary care and as smooth as possible, without nailheads,
IX. Painted iron..

4. I quite concur with Colonel Cotton in his views of the increasing importance of this subject, but I am compelled to differ from him as to Madras being a fit place for the experiments, or the Central Office the proper Agency for conducting them.. In the first place if they be undertaken here, they must be made on small models, which give results very different to those obtained on the full scale, and lead to fallacious conclusions which detract effectually from the practical value of the experiment. and in the second place, the attention of the Central Office cannot be given, with effect, to executive operations, such as these experiments involve, nor can the time of its members be spared without impeding the despatch of its legitimate business..

5. I would prefer the experiments being continued where they were begun, and as a Naval Officer, with mechanical attainments of a high order, has been nominated to the Godavery Division. Dowlaishweram would appear to be the

the fittest locality, and Captain Rundall, assisted by Lieutenant May, the proper Agent for carrying them on. On the other hand Rupees 1500 / Five hundred, at which Colonel Cotton Estimates the Cost, will not go far in experimenting on the full scale, but being averse to recommend any larger outlay, I leave the question in the hands of Government.

I have the honor to be

Sir,

Your Most Obed.t Servant

Central Office P.W.D.
Fort St. George
18 November 1857.

A. Cotton Colonel
Chief Engineer

A.C.

Further Jan 18 Nov 20–21

Further Cor 2781

Jan 1862

Nº 2493

Nº 28 Rec 25 Dec

Public Works 1857 Dept
Comm 8 Dec 31 Nº 2316

from (31)
The Chief Engineer
To the Secretary to Government
P.W. Department

Nº 3183 / Nº 3185 November 1857
Nº 2783-8 Rec 10 Dec

Nº 5293

Military order

Forwards copies of a letter and enclosures from Colonel A. T. Cotton on the subject of continuing experiments lately made at the Godavery on the resistance of boats, and recommending their continuance at the estimated cost of Rs 500 — under the Superintendence of Lieut. Connell — States that on the Coast Madras appears to be the best place for the experiments near the Central Office the presidency for conducting them, that Lieut. Connell as he has already and Captain Rundall Assistant by Mr. Clay as the proper agents for same — applied for being employed for experiments on a large scale, and the Chief Engineer being desirous to recommend Captain Rundall because the expense

Nº 2283

The Right Honorable the Governor in Council authorizes the sum of Rs (500) Five hundred being placed at the disposal of Colonel A. T. Cotton, Commander of Engineers, for continuing the experiments lately made at the Godavery on the surface friction of boats. Colonel Cotton will be at liberty to make his own arrangements for carrying out the above experiments.

Fort St George
8 Dec 1857

9 Copies to the Chief Engr Dept-9