

Educational (1898) Department.

ORDINARY MS.

G.O., No. 61

DATED 2. 2. 98.

INDEXED. 8-8

WLL-986
2-2

[Despatch Abstract.]

Comg: to the Suplt, Govt Museum, Madras
From: P.W.D. passing orders on the Conduct
of the Officer responsible for the failure
of the Coimbatore Free Library at Madras
directing that the tower be levelled with
the ground & that proposals for reconstruction
the archway between the library & museum
be submitted; & circulating the papers
to the Dept. generally for guidance:

BACK PAPERS.

G.O.	No.	Department.	Date.	G.O.	No.	Department.	Date.

FURTHER PAPERS.

G.O.	No.	Department.	Date.	G.O.	No.	Department.	Date.
20904/98							

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Educational (189) Department.

CURRENT No. 97

From The Public Works Dept

Order no 61 d 2. 2. 98
mis. Comm'd to the Supdt
Govt. Museum.

R. No. 56.

Dated

Received

Registered

Enclosures one [G.O. No. 35270 d 16.12.97.]

Spare copies.

SUBJECT.

Transferring Pro: No. 35270 d 16.12.97
Regarding the Connemara Free Library
to the Educational Dept.

Supdt. J. Museum

1/2 of one + A of current
+ order.
5/2/98.

BACK PAPERS.

G.O.	No.	Department.	Date.

FURTHER PAPERS.

G.O.	No.	Department.	Date.

BUILDINGS AND ROADS.
CIVIL WORKS.

Government {1897} of Madras.
PUBLIC WORKS.

Recd.

Regd.

} 1897.

Enclosures

Spare copies

G.O., No. 3527 W., 16th December 1897.

DECEMBER.

Connemara Free Library

Passing orders on the conduct of the officers responsible for the failure of the — at Madras, directing that the tower be levelled with the ground and that proposals for reconstructing the archway between the Library and Museum be submitted, and circulating the papers to the department generally for guidance.

GOVERNMENT OF MADRAS.

PUBLIC WORKS DEPARTMENT.

Buildings and Roads.
Civil Works.

READ—again the following paper:—

G.O., No. 762 W., dated 15th March 1897.

READ—also the following papers:—

From the Consulting Architect to Government, dated 20th August 1897, No. 1446.
From the Consulting Architect to Government, dated 7th September 1879, No. 1602.*Note by the Acting Chief Engineer on the failure of the tower of the Connemara Free Library, Madras.*

An approximate estimate for this building, amounting to Rupees 3,04,270, was submitted for sanction by the late Consulting Architect Mr. H. Irwin, C.I.E., in April 1890, and was sanctioned in G.O.,

Construction.

No. 1264 W., dated 2nd May 1890. The Consulting Architect was, at the same time, directed to submit detailed plans and estimates for the work as early as possible. On this estimate no remarks were made by the Deputy Chief Engineer (Major Baddeley, R.E., or by the Chief Engineer Colonel Drake-Brockman, R.E.)

A sum of Rs. 1,00,000 was provided in the year's budget for the work and the collection of materials commenced.

2. The building was planned by Mr. Irwin under instructions received from the members of Government. There is nothing on record to show that the Chief Engineer was consulted in any way.

3. Detailed plans and estimates, amounting to Rs. 3,56,255, were submitted for sanction in November 1890, and it was explained that the excess of Rs. 51,985 over the approximate estimate submitted in April was chiefly due to the greater cost of the tower, which was found necessary in elaborating the details, and to the cost of the book cases in the library. In scrutinising this plan and estimate the technical section of the Public Works Department office noted that the foundations of the main building were to be 9' deep (4' of concrete and 5' of brickwork), and of the tower 11½' deep (7½' of concrete and 4' of brickwork), that the tower was to be 177' in height to top of finial, and that the materials of the basement were to be stock bricks in mortar and of the walls of superstructure—Clayton's press bricks in mortar. It was also pointed out that, considering the height of the tower (177') and the nature of the soil (clay), the depth of the foundations seemed insufficient, but that it was stated that they had already been laid. On this note Major Baddeley, R.E. (Deputy Chief Engineer), suggested that the tower might be omitted or considerably reduced in height on the ground of its cost and of the fact that seven floors consisting of rooms 16' square was scarcely a convenient arrangement for a residence or an office. Colonel Pennycuik (Chief Engineer) in a note printed with the below mentioned Government Order adopted this suggestion in the following words:—

"It is worth considering whether the tower might not be reduced in height by the omission of three of its stories."

4. The plan and estimate, amounting to Rs. 3,56,255, were sanctioned in G.O., No. 3239 W., dated 6th December 1890, and the Consulting Architect was directed to report on the suggestions made in the note by the Chief Engineer.

There is no record of any calculations of the weight and stability of the tower having been made either by the designer or by the professional advisers of Government.

5. In response to the above orders, the Consulting Architect reported that the height of the tower and the number of rooms in it were designed chiefly to secure a handsome feature in the group of buildings and that he thought it would injure the design to reduce the height.

This view was accepted by Government and in G.O., No. 30 W., dated 6th January 1891, the building was ordered to be constructed in accordance with the sanctioned design.

6. The work proceeded under the supervision of Mr. Irwin, the Upper Subordinate in charge being Mr. P. Mahony, Honorary Assistant Engineer, and the contractor T. Numberumal Chetti of Madras.

The different portions of the tower were completed about the dates given below:—

First storey	...	...	...	...	...	...	...	November 1891.
Second	„	...	...	...	...	...	...	March 1892.
Third	„	...	...	...	...	...	...	November 1892.
Fourth	„	...	...	...	...	...	...	February 1893.
Fifth	„	...	...	...	...	...	...	March 1893.
Sixth	„	...	...	...	...	...	...	November 1893.
Seventh	„	...	...	...	...	...	...	October 1895.
Eighth	„	...	...	...	...	...	...	March 1896.

The wooden pinnacle was in course of erection in February and March 1897, when signs of failure became visible and the work was stopped.

7. In December 1893, a revised estimate, amounting to Rs. 5,50,566, was submitted for sanction, being an excess of Rs. 1,94,311 over the sanctioned estimate. No plans seem to have been submitted with this revised estimate, although it included provision for alterations in the design of the tower and for raising its height from 177' to 200'. The only reference made to this proposed increase of height is in the remark column of the comparative statement submitted with the revised estimate, where a net increase in cost of brickwork of Rs. 3,490 is said to be "due to changes in design considered to be advisable in working out the details, and to an increase in height proposed to be given to the tower," and additional plastering and length of lightning conductors are stated to be "due to extra height of tower."

8. The large excess over the original estimate was chiefly due to insufficient rates provided in the latter, additional works considered necessary and to changes in design. As regards the tower, the excess was Rs. 30,321, made up as follows:—

Item number.	Description of work.	Amount of excess.	Remarks.
		Rs.	
1	Concrete in mortar	876	Due to additional work found necessary owing to a slight settlement.
2	Brickwork in foundations	481	Due to extra depth to tower foundations having been carried out.
3	„ superstructure	3,490	Due to changes in design considered advisable in working out the details and to an increase in height proposed to be given to the tower.
4	Cutstone work in floors and cornice mouldings.	4,244	„ „
5	Terracotta work	2,319	„ „
6	Pallaveram cutstone for ornamental work, arches, brackets, columns, &c.	12,584	Due to changes of design, the details of the tower not having been worked out when the original estimate was prepared.
7	Decorating corner tower in cement	400	
8	Cast-iron pipes	575	Substituted for gargoyles.
9	Clock and dials	2,200	Not provided in the original estimate.
10	Iron railings and spiral staircase	800	Due to change in design.
11	Minor items	2,352	
	Total ..	30,321	

9. It will be noted from item 1 that some settlement apparently occurred in the early stages of the work. There is no record of this having been reported. It will also be seen from items 3, 4, 5 and 6 that not only was the weight of the tower greatly increased by additions to its height, but also by the employment of stone weighing 170 to 180 lb. per cubic foot and terracotta weighing 150 lb. per cubic foot instead of brickwork weighing 125 lb. per cubic foot.

10. About the time that this revised estimate was submitted the tower had been built to the sixth storey, *i.e.*, to a height of $104\frac{1}{2}$ ', and Mr. Irwin appears to have had some doubts of its stability, for there is on record in the Consulting Architect's office a paper giving calculations of the weight of the tower, of which the following is a copy:—

TECHNICAL INSTITUTE.

Weight of tower at different levels.

	Weight per square foot.	Total weight.	Remarks.
	TONS.	TONS.	
Foundation	50	746.92	Area of bottom of concrete 1,490 square feet.
Tower $104\frac{1}{2}$ ' high from ground level	7.665	2,146.32	Area at top of plinth 280 square feet.
Upper part of the tower 82' high	..	1,006.38	

This document is neither signed nor dated. But the remarks are in Mr. Irwin's handwriting, and there is a pencil entry of the weight of Madras rails as if it was intended to test the portion of the tower already built with them, as the number of rails required to weigh 1,006.38 tons is given.

11. It will be noted that—

(1) the total height of the tower is given as $186\frac{1}{2}$ ', whereas the revised design shows 200', to which latter height it was actually built, with the exception of the pinnacle;

(2) the maximum total weight of the tower is taken as 3,152.7 tons, whereas the actual weight, see paragraph 18 *infra*, was 4,539 tons. This error was due to the fact that no details of the upper portion had been designed when this estimate of the weight was made, and much heavier material was actually used than was apparently, at this time, contemplated. Both in design and material the tower, as built, was much heavier than the design sanctioned in the original estimate, which design alone was ever seen in the Public Works Secretariat;

(3) even if the figures given are taken as correct, the weight on each square foot of plinth area exclusive of scaffolding and wind pressure is $\frac{3152.7}{280}$ tons, or 11.26 tons, which is more than double what it ought to have been.

12. The revised estimate was received in the Public Works Secretariat, as stated in paragraph 6, in the form of a comparative statement and without a plan. The note in the technical section was confined to calling attention to the causes of excess.

Major (now Lieutenant-Colonel) O. V. Boddy, R.E., who was at the time Deputy Chief Engineer, in submitting the estimate to the Chief Engineer (Colonel Pennycuik, R.E.) for orders, made the following remarks: "I think that all except really necessary work should be excluded from the estimate. I think that this very large excess in the estimate, which must have been foreseen long ago, should have been brought to notice earlier. Some of the deviations involve large sums, and should, I think, have received the sanction of Government before they were undertaken. Change in the design of the tower has cost some Rs. 30,000."

Colonel Pennycuik, however, directed that the estimate should be sent up for sanction in its entirety, attention being called to the irregularity noticed by his deputy, and the revised estimate was sanctioned in G.O., No. 818 W., dated 28th March 1894.

13. There is no record at this period, any more than when the original estimate was sanctioned, of any calculations being made in the Secretariat of the weight and stability of the tower.

14. In January 1896 Mr. Irwin retired from the service, and the duties of Consulting Architect were undertaken by Colonel C. C. Rawson, R.E., Superintending Engineer, V Circle, in addition to his

Failure.

own, until October 1896, when Mr. G. S. T. Harris, Executive Engineer, was appointed to the post.

15. The latter officer at once saw that that portion of the library adjacent to the tower was being pulled forward by the superior weight of the tower, and that the key stones of the arches connecting the tower with the museum were falling out from the same cause. The effects of the movement were, and still are, visible on the library side for a length of 50' to the south and 40' to the north of the tower. The building was opened in November 1896, and in November and December of that year the whole connection of the tower with the museum above plinth level was removed, and two bays of the library have been since demolished and rebuilt.

16. The Consulting Architect had, however, no suspicion at this time that anything was wrong with the tower. As stated in paragraph 5, the wooden pinnacle, which was to complete the tower, was in course of erection in February and March 1897, when Mr. Harris noticed that the terracotta cornice in east face of one of the tower piers was cracking and falling off. Closer examination showed numerous thread-like cracks in the brickwork, and new cracks appeared daily in the terracotta cornice. It was evident that crushing was going on at an alarming rate. The following letter, dated 7th March 1897, from Mr. Harris, to the Chief Engineer Colonel Campbell, R.E., is given in full, as it clearly explains the situation at this time:—

"I have the honour, in compliance with your order of this morning, to submit the following report on the tower of the Connemara Library and Museum.

"2. It will be as well to here detail what has occurred which led to my urgent visit and demi-official letter to you, yesterday, the 6th instant.

"3. From the time of my taking up the appointment of Consulting Architect, I have been very anxious about the safety of the new work adjacent to the tower, for I saw that unequal settlement as between the tower and adjacent buildings was going on. I recognised that this was inevitable, because of the enormous disparity of the foundation loads. On this premise—and only on this premise—I made it my business to carefully watch the cracks, and at times to plumb the walls of these adjacent buildings, believing that danger to these only existed. It never occurred to me to doubt the stability of, or to call in question the design and material composition of, the tower itself.

"4. About three months ago I determined to take down the neck, or the single bay, connecting the tower entrance with the verandah of the new museum, for the key stones were slipping through, the arches of the museum verandah were working out of shape, and the antæ piers at either end were getting a little out of plumb. This work was dismantled and at the same time I had the centre arches propped up.

"5. Again it has all along been apparent to me that the two octagonal-headed bays, those next to, and right and left of, the tower would have to be dismantled and reconstructed, but it seemed to me that the proper time to do this would be when the tower settlement had ceased. I found lately that these bays were getting worse, that the mullions of the windows were getting more out of the perpendicular, that the soffits were more out of level, that the brick quoins were bulging, and that some detrition had started in the brickwork itself; in fact that the octagonal-headed bays were parting from the main walls. It was my intention to erect gables to prop these up; this was a few days ago.

"6. On Friday, the 5th instant, I went out with Mr. Mahony on inspection and afterwards took him to the museum. I then noticed for the first time a crack in the terracotta cyma moulding, forming the capital of the four pediments supporting the tower: this I attributed to some defect in that piece of terracotta, but, on further examination, I found small thread-like cracks in some of the bricks, and I immediately concluded crushing was proceeding and told Mr. Mahony so.

"7. I here state, positively, that it never occurred to me till Friday morning to question what were the materials the tower was built of. I felt certain that the bricks were selected pressed bricks set in cement mortar.

"8. I at once asked Mr. Mahony if the bricks were not all pressed. He said, as I then understood, 'No, Sir; only the face bricks. The hearting is all of stock brick.' I said: 'Are you quite sure?' He replied, 'Absolutely.'

"9. I went at once to office, and wrote the urgent letter to you, that you got on Saturday, and ordered Mr. Mahony to purchase 200 feet of log line and to be at the museum with it, and

a 28 lb. weight next morning, when I found such an alarming increase in the cracks, that I posted men on each side to warn people, and saw Mr. Bourne and warned him. I told Mr. Mahony to have carried down all loose material in the tower and I then drove straight to your house to see you.

"10. You requested me to meet you at 12 o'clock at the tower. You then examined it with me, and I found I was mistaken in believing the face bricks were pressed, for Mr. Mahony told us 'the face bricks are only oil-moulded, not pressed, the others are the ordinary stock brick.' This rendered the position perhaps more unfavourable.

"11. At your direction I saw you again in office, when you determined to call an informal committee of Engineers for this morning (Sunday 7th).

"12. So this morning there was present at the tower with you, Mr. Hughes, Mr. Fowler and myself: shortly after Mr. West arrived, and he kindly gave us his opinion.

"13. We examined, first, the library bays with the result that Mr. Bourne was asked to remove all books, &c., from them, and they were considered to be in so dangerous a condition that I understood they must be dismantled at once.

"14. We then discussed the materials and the plan. I explained that the mortar consisted of shell lime and sand (1 of lime 2 of sand): that this had been used through and through, that is in the middle of the thick piers, and I further stated my belief that such fat lime (pure lime) had no setting powers, beyond the surface layers, and that it would be either in a pulp, or, if dry, like powder in the middle of the work.

"15. Then, as to staircases, we found that in places the brickwork was $1\frac{1}{2}$ bricks or 15" thick, the whole way up, and that supposing Flenish Bond (probably the best bond for such thin work) had been employed at those points where the $1\frac{1}{2}$ to 2" Cuddapah slabs of the circular staircases had been inserted, the weakness of the wall was very marked.

"16. Next the staircases were examined—to the first floor—nearly every tread, if not all, were snapped across in one or two places; in one place where the mortar was stripped off the wall of the staircase, the brickwork was found very rough, with large coarse joints.

"17. After this the cracks in the brickwork of the piers were examined. You and I found fresh cracks in places where we had not observed them on Saturday and lower down.

"18. The dismantled bricks and mortar of the neck taken down were now examined. This material, Mr. Mahony asserts, is identically the same material as is the tower. The mortar was found to be of no strength, and this was work erected two or three years ago.

"19. The officers present were then individually asked their opinion as to what was taking place in the piers of the tower, they were all unanimous in saying that crushing was proceeding.

"20. I decline, without more time, to state what the actual weight imposed directly and indirectly on each superficial foot of the weakest of the piers is, till I have had time to carefully take it out; it must be remembered that the tower from top to bottom was lately encased in heavy scaffolding inserted into put-log holes, that the tower is ever subjected to wind pressure, and that neither of these was considered. The weights shown in the schedule I brought with me this morning were taken from the quantities of the revised estimate—and more or less as work done, and mostly paid for. Then again it must be decided on, in association with others, what the effective area of the weakest pier is—so must be determined the weights of the various materials.

"21. These calculations do not so much call for urgency, as do the orders which must be issued, viz., what is to be done to the tower—if it is to be at once dismantled—and how it is to be done. I this morning gave my views."

17. On this letter Colonel Campbell wrote the following note for the orders of Government:—

"The demolition of the tower will be a tedious, difficult and dangerous operation, and before this is decided on I would suggest that Mr. Irwin, who designed and carried out the work, should be asked to make proposals as to how the tower can be supported. I have spoken to that gentleman and he is very anxious that he should be given an opportunity of submitting a design by which the demolition of the tower may be avoided. The failure of the tower is due to the materials used not being of sufficiently good quality to withstand the enormous pressure to which they are subjected.

"Some rough calculations have been made which show that the weight is much over the crushing strength of the materials, but these calculations have to be checked and gone into carefully: when this is done a further report will be submitted. In the meantime early orders are solicited as to whether the demolishing of the tower should be begun at once or Mr. Irwin's proposals awaited. I recommend the latter course."

18. The committee referred to in the above note was appointed and made its

Demolition.

report which will be found in G.O., No. 762 W., dated 15th March 1897, attached. Mr. Irwin, the late Consulting

Architect, was granted an opportunity of giving his opinion regarding the stability of the tower, and did so in a letter to Colonel Campbell, R.E., dated 9th March 1897. He advocated the first method for supporting the tower which was considered by the committee, namely, "to encase each of the piers in an iron cylinder, and fill in between with cement concrete." The committee, as will be seen, adopted none of the proposals for supporting the tower, but recommended its demolition as far as the second floor. This was approved by Government and taken in hand at once and completed by 20th August 1897, without accident to any one and with very little damage to the materials.

19. It will be seen that the committee reported that "the cause of the crushing was undoubtedly the faulty design of the tower by which too great a weight is thrown on the piers, the weight that they have to bear is no less than 23 tons per square foot, while we are of opinion that 4.5 tons is the greatest pressure they can sustain with safety."

It may be well to record here how these figures were arrived at and the following gives details of the calculation:—

WEIGHT OF CONNEMARA LIBRARY TOWER.

Quantities as per estimate.

Quantity.	Description of work.	Weight.	Total.
62,516 cub. ft.	Brickwork	130 per cub. ft.	8,127,080
5,717 "	Stonework	180 "	1,029,060
2,290 "	Terracotta	150 "	343,500
698 "	Woodwork	50 "	34,900
1,653 sq. ft.	Doors and windows	5 per sq. ft.	8,265
"	Steel girders	"	13,440
"	Wrought iron work	"	1,473
			4,072