

No. RW/N-3&4/MAH/2379/W

Dated the 22nd November, 1983

Sub: Problems and practice of grouting of ducts for post-tensioned cables in prestressed concrete Bridges

As desired by Additional Director General (Bridges), copies of D.O. letters dated 17th August, 1983 from Additional Director General (Bridges) to Dr. Ing. Fritz Leonhardt, his reply dated 26th August, 1983 and ADG (B)'s letter to him dated 2nd September, 1983 on the above subject are enclosed herewith to all Officers of the Bridges Directorate for information and guidance.

Enclosures to circular No. RW/N-3 & 4/MAH/2379/W

Dated the 22.11.83

D.O. LETTER NO. RW/N-3&4/2379/W DATED THE 17TH AUGUST, 1983 FROM ADDITIONAL DIRECTOR GENERAL (BRIDGES) MINISTRY OF SHIPPING & TRANSPORT (ROADS WING) TO DR. LEONHARDT, STUTTGART-I (WEST GERMANY)

I have great pleasure in seeking your valuable opinion and advice on the problem faced in grouting of the post-tensioned cables in the prestressed concrete beams of an important bridge situated on the sea coast. Our experience of another bridge with prestressed concrete superstructure completed only about 15 years ago near the sea at Bombay across a creek, has been sad on account of corrosion of the prestressing cables, some of which have also snapped endangering the safety of the structure. I am, therefore, impelled to refer this instant bridge under construction to avoid repetition of mistake affecting the durability and long-term serviceability of the bridge.

2. To describe briefly, the superstructure consists of two precast prestressed concrete beams with simply supported spans of nearly 50 metres each, launched into position after initially tensioning the cables required for supporting the self-weight and the deck slab. The deck slab of reinforced concrete laid over the beams is to act in composite with the beams by the provision of shear connectors. For imparting subsequent stages of prestressing, cables are anchored in the top flanges of beams (in the deck slab portion) after superimposed dead loads like wearing coat, hand-rails etc. are applied. These are about 30% of the total number of cables, which were left in position during the concreting of the precast beams in order that they may be tensioned finally for resisting the live loads, etc. and the tension is allowed in the design under service conditions. Freyssinet system of prestressing with each cable comprising of 24 nos. of 8 mm dia, parallel wires is adopted. Accordingly the problem has arisen for tensioning the cables at the final stage prestressing, as stated in the next para.

3. These cables were left inside the metallic sheathing lining the ducts in the forms before concreting of the beam in the precasting yard and the usual precaution of sea-saw operation (to loosen cables) was taken during concreting of the beam to safeguard against the cables getting stuck up by leakage of mortar. But while stressing and grouting the previous stage prestressing cables, some of which were also grouped in the mid span portions, apparently no step was taken to ensure freedom of the balance cables to be stressed after launching of the beams, etc., as mentioned above. Further, the anchorages of these cables were sealed temporarily with lean concrete for allowing the trolley line on the beams previously launched for carrying the beams to be launched in the subsequent spans. Now during the final tensioning of these cables, barring a few cables stuck up, the rest have been stressed more or less to the required elongations and forces. But the real difficulty came up in the process of grouting of these cables. Prior to grouting, flushing by water in the ducts indicated blockages which did not permit escape of the water through the exists provided or through the other ends. It is suspected the grouting mortar of the cables previously tensioned penetrated into the ducts of these cables. We are unable to locate the points of such blockages nor remove the obstructions otherwise. Any crude method of locating the blockades and chipping and concrete at these points to free the cables, however, is not desirable due to the risk of damaging the structure. Some literature published regarding the radiographic examination of the cable profile adopted in developed countries as well as sonic devices is available, but their use is not known in our country. I am confident that such problems might have been encountered in your country and naturally, we would like to be guided by your experience in the solution of the problem.

4. Another concomitant issue is that delay by a few months has taken place in grouting of the tensioned cables (though grouting is insisted within 48 hours) because of the deleterious consequences feared in an aggressive marine environment, like ordinary corrosion as well as probably stress corrosion. It may be stated for your kind information that the tendons are not galvanized or epoxy coated and specially treated for eliminating corrosion. What measures are warranted under the circumstances to inhibit the occurrence of corrosion of cables? I should like to be enlightened whether there is any practice in your country to give such protective treatment against corrosion of cables.

5. I would also like to know how to ensure that grouting has been effectively carried out and cables are fully covered inside the ducts without any voids even after the shrinkage of the grout, etc.

6. I shall be obliged, if you can kindly spare your precious time and offer us the benefit of your experience in this connection.

Dr. Leonhardt's DIO. letter dt. 26.8.1983 addressed to ADG (B)

I have received your letter of 17th August, 1983 and understand your worries. You described typical deficiencies of prestressed concrete beams designed following the French way, using tendons which are anchored at the surface of the roadway slab. We have abandoned this type of design many years ago. In addition, we have specified rather strong and absolutely tight ducts in order to prevent any intrusion of mortar. We have further very strict specifications for the grout and for the grouting process because all that is most important for the durability of the bridges.

I am sending to you our latest specifications for the grout, part 5 of DIN-4227.

In the case which you describe, it is most important to remove the blockade of the cables. This can perhaps be reached by repeated stressing and unstressing, by which the blocking mortar can be broken and grinded and then spilled out by water jetting. If this does not succeed, then it would be necessary to find the location of the blockade at least approximately by measuring the elongation of the cable for a known stressing force. Then one should drill holes from the outside to the duct on both sides of the blockade, so that the grout can be injected through these drilled holes. In such cases we use the vacuum method which makes sure that all voids will be filled.

The delay of the grouting can, of course, have caused corrosion of the wires in the ducts and therefore, these wires should be specially treated before the grouting, may be by flushing with lime white wash, which has an alkaline PH-value.

I have tried to contact Professor Rehm of our Otto-Graf-Institut, University of Stuttgart, who is our specialist for these problems. But, unfortunately, I can not reach him before the middle of next week. His advice may be helpful in this matter.

Successful grouting requires a lot of special knowledge and also of very strict control. You may perhaps engage one of our specialists for informing some of your engineers. Mistakes in grouting have also been made in our country, and we have found quite a number of bridges where the ducts had not been perfectly filled with grout and the prestressing steel corroded. This was mainly due to lack of diligence at the execution of the work. Personally, I suggest more and more to use the vacuum method, for which the patents expired about a year ago, so that it is now available for general use.

I am sorry that I cannot help you in a better way at the moment. As soon as I can reach Professor Rehm, I shall ask him to write to you his advice for the anti-corrosive treatment of such wires.

D.O. LETTER NO. RW/N-3&4/2379/W DATED 2ND SEPT. 83 FROM ADDL. DIRECTOR GENERAL (BRIDGES), MINISTRY OF SHIPPING & TRANSPORT (ROADS WING) TO DR. LEONHARDT, STUTTGART (WEST GERMANY).

I acknowledge with thanks the receipt of your kind letter dated the 26 th August, 1983 alongwith one copy of the latest German specifications for the grout for the ducts of prestressed concrete cables. Many thanks for your prompt reply. We have really benefitted from your advice in the problem.

- 2.1. The course of action suggested by you regarding the removal of blockade in the cable ducts was thought of by us also. Practical difficulty in carrying out the field operations after the beams are already launched in position is hampering our move in this matter.
- 2.2. We would like to get the literature about the vacuum method, referred to in your letter.
3. As regards corrosion of wires in the ducts caused by the delay in grouting, we would like to hear further your esteemed views after contacting Prof. Rehm as soon as possible.
- 4.1. Specifications for the grout contained in latest DIN 4227 would be made use of after getting translated from German.
- 4.2. To obtain an accurate English translation of any technical document in German is somewhat difficult in our country. In case an English translation of this particular German Specification is available, kindly arrange to send a copy for our immediate use.
5. It has also been educative to note the design with anchorages for tendons at the surface of the roadway slab being abandoned in your country.
6. We are, indeed, grateful to you for all the pains taken for rendering your quick and valuable advice. Hope to hear from you further.