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The condition of partially prestressed concrete structures after 3 to 7 years' use

Der Bauzustand von teilweise vorgespannten Beton-Konstruktionen nach 3-7 Jahren Gebrauch

Estado de conservação de estruturas de betão parcialmente preesforçadas depois de 3 a 7 anos de utilização

Etat de structures de béton partiellement précontraintes après 3 à 7 ans d'usage

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In [1] the author has referred to a partially prestressed concrete structure type (i) (B) introduced by the Chief Civil Engineer's Department of British Railways, Eastern Region. In this case freedom from cracks is obtained in spite of relatively high concrete tensile stresses appearing under working load, i. e. 650 to 750 lb/in^2, for bridges and roof constructions respectively. It is believed that this kind of design, which was originally considered by many experts as inadequate, is unique

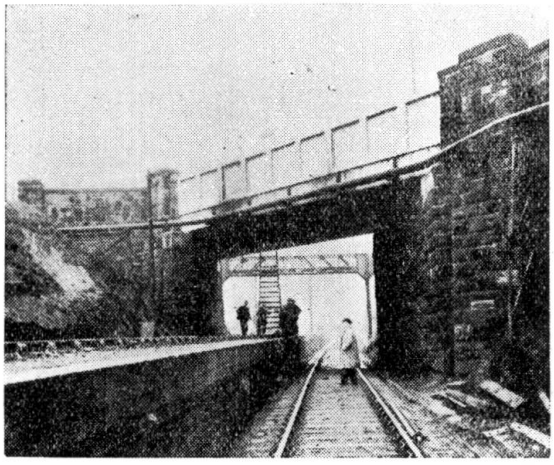

FIG. 1

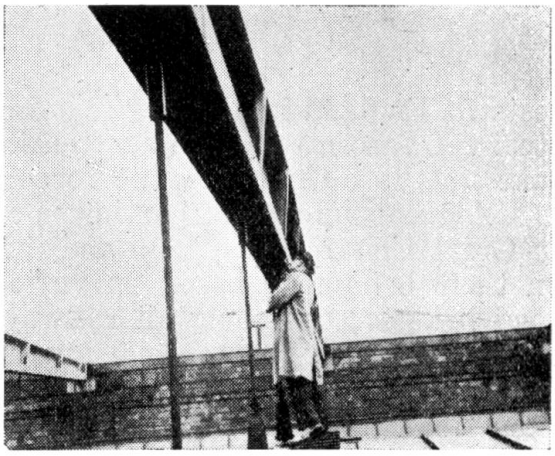

FIG. 2

except for certain constructions built in Germany where a somewhat similar type was introduced under the name «Beschränkte Vorspannung» (limited prestress) for which concrete tensile stresses up to 560, 700 and 850 lb/in² (40, 50 and 60 kg/cm²), corresponding to the concrete strength, were permitted for structures strained in bending in one direction. However, it is required in the German case that sufficient non-tensioned conventional reinforcement is available to carry the *entire* tensile force which would occur for the resultant elastic stress distribution if the concrete tensile zone did not co-operate. An appreciable amount of non-tensioned steel has thus to be provided which is in fact not required, as extensive

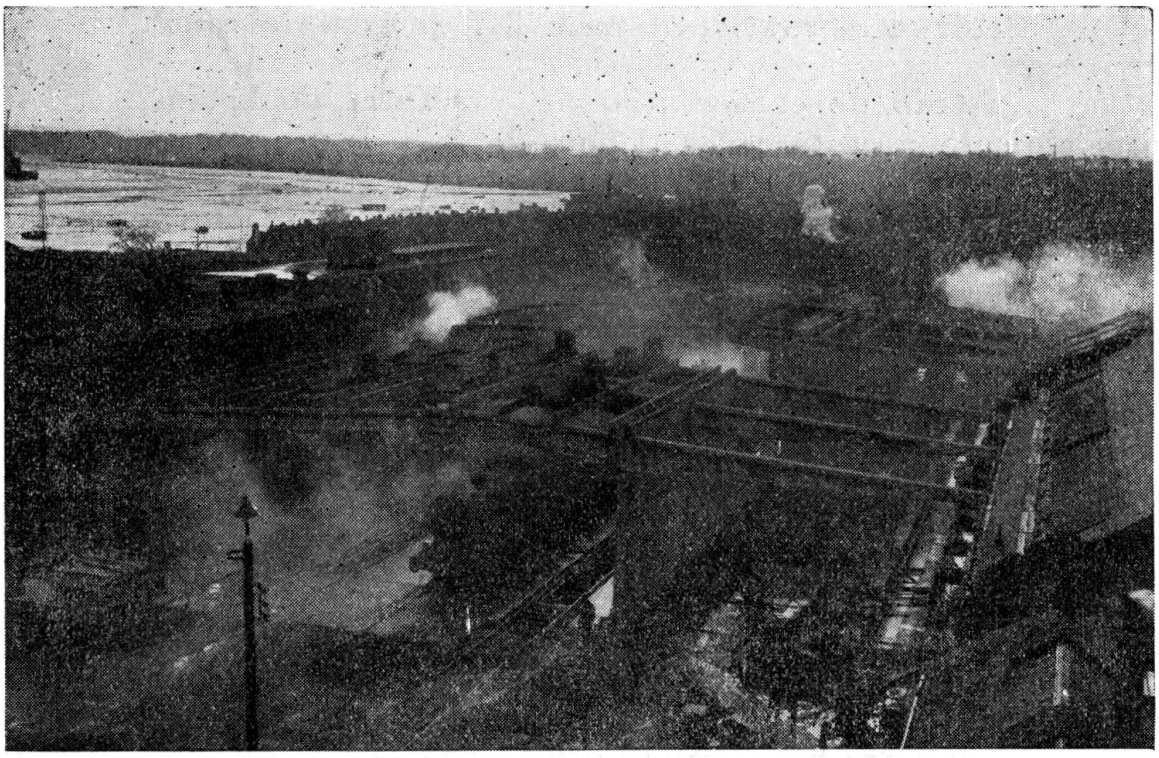

FIG. 3. Smoke development in Engine Shed, Ipswich

tests in England have shown; it is in fact only necessary that the entire steel reinforcement, whether tensioned or non-tensioned, is sufficient to take up the ultimate tensile force at failure.

A great number of partially prestressed constructions have been built in Great Britain since 1949 and it may therefore be of interest to report on their behaviour based on various inspections. First, with regard to road bridges; obviously all railway-owned road bridges are inspected at certain intervals, but special investigations were made at two bridges in September 1954; the soffites of the bridge constructions were carefully examined when at the same time a heavy lorry, corresponding to the maximum loading, crossed the bridges. Another examination was carried out early in 1955 when a loading test was carried out together with

deflection measurements [2]. A further inspection in May 1956 related to a skewed bridge of 50 ft. span which is particularly affected by smoke owing to the continual passing and repassing underneath of a colliery steam shunting locomotive at a pit near Rotherham (Fig. 1). Also this examination was very satisfactory (1).

Another application relates to roof constructions for which the required live load is 15 lb/ft² for snow and wind, because the roofs are not accessible. It is true that in England snow occurs rather intermittently, nevertheless this must be considered since full snow load may take place for a considerable time occasionally. For example, in the winter

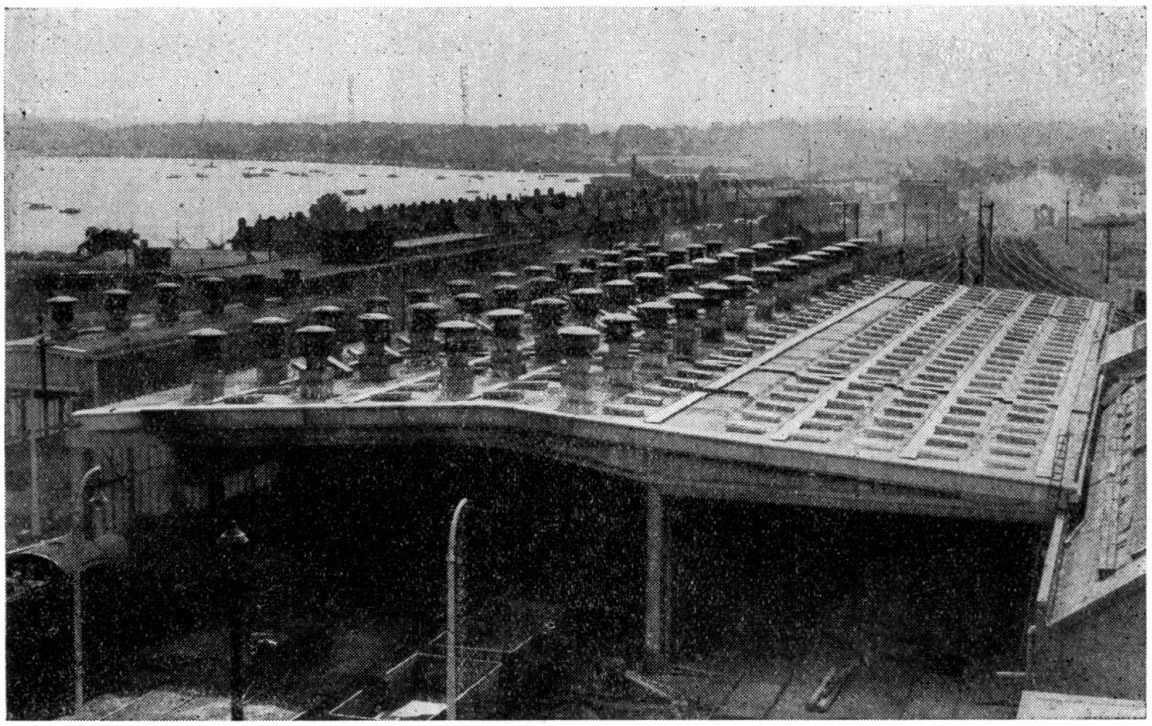

FIG. 4

of 1955/56, snow remained one to two months on most of the roofs discussed in the following. An inspection took place in April 1956 of the several roof constructions, e. g. of the Depot at Bury St. Edmunds built in 1952, described in [3]. Particulars of the examination in May 1956 of the main beams of 85 ft. span on the Victoria Station Roof Sheffield, built in 1953, are seen in Fig. 2.

Figs. 3 and 4 are views of the Engine Shed, Ipswich, built in 1953, which was examined this year and proved fully satisfactory (2). This

(1) All these bridges, except that at Rotherham, were built to obtain greater head room for the overhead wire required for electrification of the railways. However, much steam traffic still occurs and instead of smoke plates metallurgical supersulphated cement has been successfuly used. No sign of any damage due to smoke has been noticed.

(2) In some quarters it is thought that a particularly high factor of safety against cracking would be necessary where heavy smoke occurs, such as in an Engine Shed. However, any snow will immediately melt as long as the engine shed is in use and thus little such live load will occur. On the other hand, snow may remain on the roof when the engine shed is temporarily out of use.

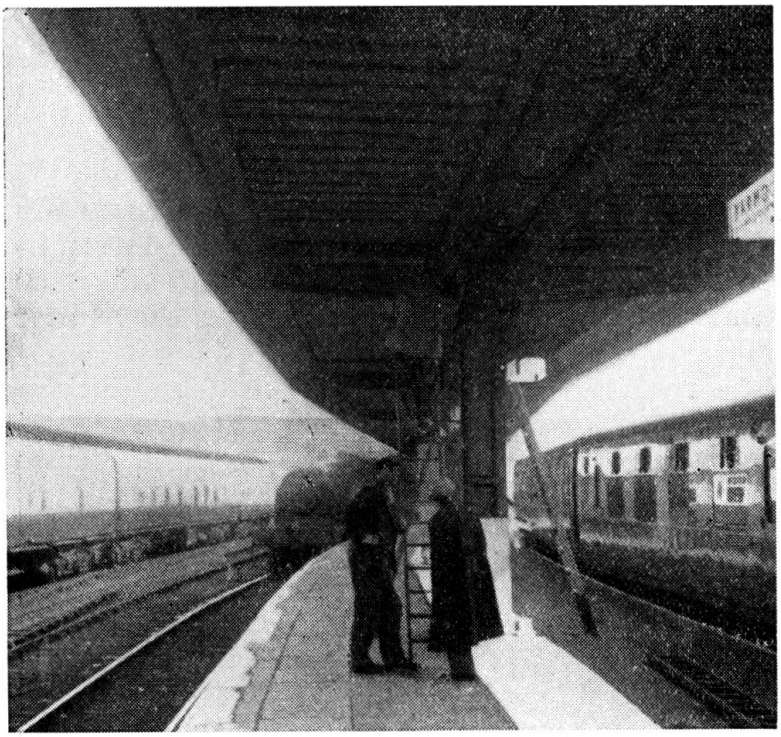

FIG. 5

roof contains 102 ft. long precast roof beams with post-tensioned cables and precast purlins with pre-tensioned wires. Fig. 5 shows the inspection of the platform roof at Yarmouth, built in 1953, containing 40 ft. long purlins 14 in. deep with pre-tensioned wires. In this case, both smoke and sulphate in sea air has not noticeably affected the construction. In Fig. 6 the platform roof at Grays built in-situ in 1953/54 is seen, which was inspected in 1955 with satisfactory results. The construction is a cantilever slab with a maximum free cantilever of 18 ft. 6 in. length and a depth of 4 to 5 in.

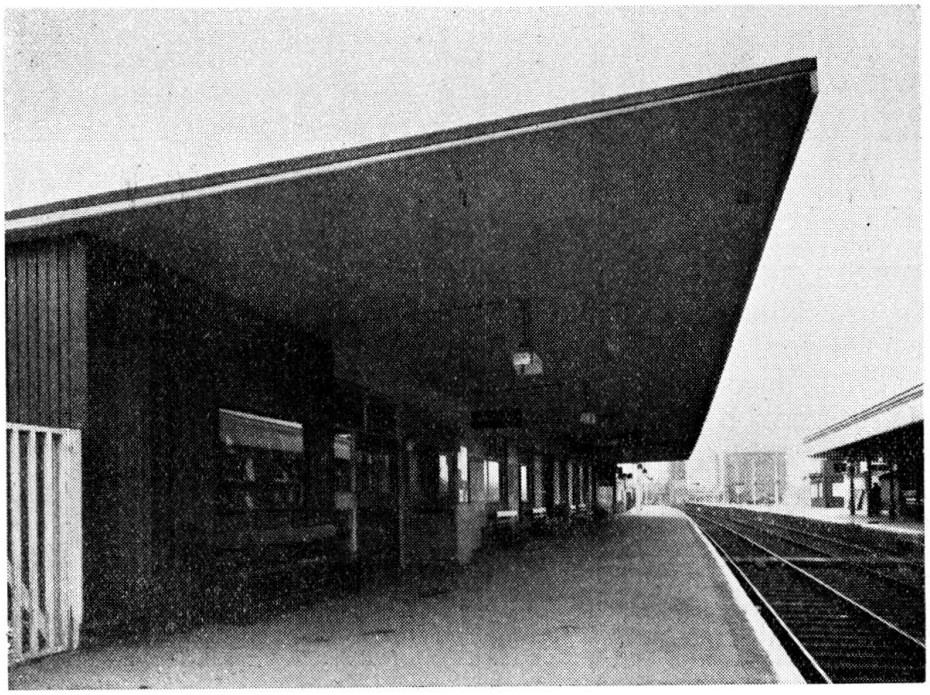

FIG. 6

By the choice of permissible tensile stresses in all these roof structures of 650 (for post-tensioned cables) to 750 lb/in^2 (for pre-tensioned

wires) freedom from visible cracking is obtained. In addition, as a further precaution all the constructions discussed have been designed on the condition that concrete tensile stresses do not occur under dead weight. Thus, any crack which might have occurred due to unforeseen excessive loading will nevertheless be closed under dead weight ([3]).

Summing up, it can thus be stated that the practical experience with partially prestressed concrete structures introduced since 1949 has proved very satisfactory. The advantage of this type of design is the possibility of a lighter or shallower construction which presents all the advantages of a fully prestressed construction except that the factor of safety against cracking is reduced. In consequence of the reduction of the prestressing force also the camber is decreased. In view of these satisfactory experiences with constructions of type (i) (B) is is hoped that its further development will no be hindered by unrealistic restrictions.

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ACKNOWLEDGMENT

The successful experience with partially prestressed bridge and roof constructions over a number of years was only possible by the fact that the Chief Civil Engineer's Dept. of British Railways, Eastern Region, was prepared to introduce this type of construction in 1948, after having been satisfied about its adequacy by satisfactory test results. A certain opposition against this type of construction was counteracted by the kind assistance of the Association to include partial prestressing in the general definition after the Congress at Liege in 1949, as mentioned in [1]. The author would like to acknowledge this with thanks.

([3]) Obviously, in all these cases a certain supervision is required to ensure that the construction is truly monolithic; the main requirement is to avoid the development of any shrinkage *before* prestressing. Such a supervision is, *generally*, advisable with prestressed concrete to obtain full agreement between finished construction and design assumption. Otherwise, the design would be based only on imaginary conditions. An arbitrary increased factor of safety does not give any measurable margin against disagreements between design and execution and can, therefore, not be considered as a replacement of supervision. Performance tests carried out at random before acceptance prove that the required prestress is effective and that the structure is truly monolithic.

SUMMARY

The conditions of various partially prestressed bridges and roof constructions built in 1948-1953 were recently investigated; these inspections proved that the state of the constructions was very satisfactory in spite of the fact that some structures were exposed to heavy smoke.

ZUSAMMENFASSUNG

Der Bauzustand von verschiedenen, in den Jahren 1948-1953 hergestellten teilweise vorgespannten Brücken und Dachkonstruktionen wurde kürzlich untersucht und hierbei festgestellt, dass derselbe äusserst zufriedenstellend ist, wobei kein Zeichen einer Rissbildung wahrnehmbar war, trotzdem die Konstruktionen heftigen Raucheinwirkungen ausgesetzt waren.

RESUMO

Examinou-se recentemente o estado de conservação de várias pontes e coberturas parcialmente, preesforçadas, construídas no período 1948--1953; estes exames permitiram verificar que o estado dessas estruturas era muito satisfatório apesar de algumas estarem submetidas a fumos.

RÉSUMÉ

L'état de plusieurs ponts et couvertures partiellement précontraints, construits en 1948-1953, a été examiné récemment; ces examens ont permis de constater que leur état était très satisfaisant bien que certaines de ces structures soient exposées à la fumée.