Zeitschrift: IABSE congress report = Rapport du congrès AIPC = IVBH Kongressbericht

Band: 6 (1960)

Artikel: General report

Autor: Kerensky, O.A.

DOI: https://doi.org/10.5169/seals-7073

Contributions libres sur des développements nouveaux importants
Freie Beiträge zu wichtigen neuen Entwicklungen
Free Contributions to Important New Developments

VI

Progrès importants de l'art de l'ingénieur. Constructions mixtes
Bedeutende Fortschritte der Baukunst. Verbundbauten
Important Progress in Bridge and Constructional Engineering Composite Structures

General Report

O. A. KERENSKY
B. Sc., M. I. C. E., M. I. Struct. E., London

In addition to the original eight papers dealt with in the Preliminary Publication, eighteen people made further written or oral contributions, some commenting on the original papers and others covering new ground. This makes the task of the reporter for this general theme even more difficult, and the allotted space will permit only a brief appreciation of the more important points made in the new contributions.

Professor G. Wästlund reported on fatigue tests of composite beams conducted at the Stockholm Royal Institute of Technology. In a joint paper with B. Bergvall he gives details of these tests. Each beam was subjected to 250,000 pulsating loadings between repeated static load tests. In 3 out of 4 cases the ultimate failure occurred in the connectors near the welds. The connectors were of the U-shaped round bar type and the results of the tests confirmed the allowable loads for this type of connector suggested in a paper by G. Wästlund and L. Oestlund published in the 1952 Cambridge Congress Report, although the pulsating loads markedly influenced the ultimate static strength of the beams by quickly destroying the bond between concrete and the flange of the beam. Nevertheless, even in the worst case, after 1.3 million pulsations the connector breaking load was 30 % higher than the allowable. The tests have shown that more than one million repetitions of loadings which produce up to and slightly over the design forces on the connectors do not change the elastic behaviour of the composite beam. They also clearly showed that concrete slabs must not be assumed to take any tension.

Dr. P. W. ABELES described some fatigue tests carried out by the Eastern Region of British Railways on composite prestressed concrete bridge decks. In his well documented paper it is shown that in the tests the added cast in-situ concrete slab satisfactorily co-operated with the precast prestressed beams, without visible cracking. Three types of interconnections between beams and slab were examined:

1. Beams with rough surfaces.
2. Beams with smooth, but castillated surfaces.
3. Beams with smooth surfaces and steel stirrups.

It was found that all three types were satisfactory as regards ultimate load even after millions of pulsating loadings but 1. was the best and 2. was the worst as regards cracking.

The tests showed that sufficient shear reinforcement must be provided to resist the high principal tensile stresses in the added non-stressed concrete due to shear and bending caused by point loads. The stirrup reinforcement is required solely in the added concrete.

Mr. J. A. FORRESTER submitted a paper describing new application of gamma-radiography to non-destructive testing of concrete, and in particular to examination of grouting in the prestressing cable ducts. The method can also be used to locate and identify reinforcement in members for which detailed data is not available.

The principle of gamma-radiography is to record on photographic film the intensity of radiation transmitted through the material under examination. The apparatus is more portable and less costly than that required for X-radiography, while the power of penetration is greater. The benefits of non-destructive testing are obvious and it would seem that this new method of examining concrete may become popular. During the discussion, Professor E. GIBSCHMANN of the U.S.S.R. gave some details of composite construction of steel beams with precast slabs in bridge-work. He stated that for repeated loadings precast units are not as satisfactory as cast in-situ and M. FOUGNIES described a very interesting new type of prestressed combined action construction used in bridges over the Albert Canal and the Meuse in Belgium. In this form of construction no shear connectors are used, the steel girders project into the concrete slab which is made to grip the steel by lateral prestressing to about 30 kg/cm^2. Mr. FOUGNIES estimated that ordinary steel or reinforced concrete bridges could not compete with laterally prestressed composite steel and concrete ones for spans up to about 40 metres.

A paper by M. LORENTSEN is an important contribution describing tests that have been carried out at the Royal Institute of Technology, Stockholm, to investigate the bond characteristics of prestressing cables. The tests showed that as a crack distributor the cable is inferior to ordinary reinforcement. Plexiglass model tests indicated the trend in the distribution of maximum compressive strain between cracks, the ratio of average to maximum strain decreasing with increase in distance between consecutive cracks.

Referring to Table 2, several points are noteworthy:

A 100 per cent efficiency of bond was assumed for grouted beams; in the ungrouted Tee-beam the inclusion of deformed bars of smaller cross-sectional area than that of prestressing tendons was sufficient to give a distribution of cracks as good as in the grouted beam, although the ultimate strength was reduced by 7.5 %. The rectangular beams were much less sensitive to grouting than the Tee-beams, the reduction in ultimate strength being $12^1/_2$ per cent and 36 per cent respectively without deformed bar reinforcement. Although the 3.5 per cent ultimate compressive strain in the concrete recommended by the European Concrete Committee was in no case achieved, it would appear that existing ultimate load formulæ are satisfactory even with imperfect grouting.

Professor H. Louis describes an investigation carried out at the University of Liege, of the bond between concrete and high tensile steel wires of different diameters and surface conditions. The bond was determined by pull-out tests and by testing model beams. Smooth and ribbed wires, both clean and rusted, of diameters of 3, 5 and 7 millimeters have been tested, each time, measuring the load at the commencement of slipping. Bond-strain diagrams for all the above kinds of wire were obtained and the inferiority of the smooth clean wire clearly established.

Professor B. Thürlimann and K. Basler, comment on the results of the tests on welded plate girders with slender webs, subjected to bending or shear carried out by Lehigh University, Bethlehem, U.S.A. The tests conclusively show that web buckling produces a gradual redistribution of the internal stresses. The post buckling strength is contributed by the web plate itself and by the boundary elements, i. e. stiffeners and flanges. The authors discuss the possible modes of failure of the compression flange and point out that in a welded girder the thin flanges have little vertical rigidity, and therefore, cannot effectively serve as anchors for a tension field in a buckled web, which therefore must be provided by transverse stiffeners. Based on these considerations they develop a formula for the ultimate shear which fairly represents the observed strength of the girders.

Professor I. A. El-Demirdash of Cairo University, regrets that no information is given by the authors on the stress distribution in the cases of shear, and of bending and shear, and suggests that strains should be measured in three directions in order to get a complete picture. It is understood that further publication by the Lehigh University giving the theoretical studies associated with the tests is in preparation. The development of theory and of rules for the design of plate girders, taking into account the post buckled strength of the thin web, should prove of the utmost importance.

A paper by S. W. BRYKIN of U.S.S.R. describes tests on carrying capacity of axially loaded concrete struts prestressed by tensioned helical wire wound around the specimen. The quality of concrete and the amount of tension were varied and the tests showed that under certain conditions the ultimate strength of such struts can be approximately 50 per cent greater than the ultimate strength of similar struts with untensioned wire. The research in this field continues. Further tests are planned to deal with hollow cylindrical struts and it is hoped that mathematical analysis will be developed to deal with elements subjected to triaxial compression, both of solid and hollow cylindrical form, and eventually design formulæ or charts produced.

A short paper by C. SCHAUB reports on the development in Sweden of a reinforcing steel with a high yield, good ductility, weldability and high resistance to brittle fracture — the C. D. (Cold Ductile) steel. The author points out that the cold working of steel, usually adopted for producing high tensile reinforcement increases the risk of fatigue and brittle failure. After more than five years of research a weldable high strength non-brittle steel bar has been successfully produced.

F. LEDERER of Czechoslovakia, describes the design of a spherical dome with a central lantern. The dome is of 93.5 metre span with a rise of 19.7 metres and was designed by applying the membrane theory, although it actually consisted of a lattice assembly of continuous steel tubes arranged in three intersecting systems, forming a network of curved triangles, able to transmit forces from all directions.

R. DĄBROWSKI makes a contribution regarding the design of Tankarville Bridge by drawing the attention to the importance of horizontal components of the forces in the hangers and deduces equations for the effect of these forces on the vertical bending moments.

Several other speakers contributed to the oral discussion, but their written contributions will be published elsewhere, namely: A. SCHMID's in Theme III; K. KONDO, K. ITO and M. NARUOKA, on bridges in Japan, and Professor E. BILLIG on the construction of Atomic Power Stations, shell roofs and other structures — in the "Bulletins"; F. FALTUS on a 327 metre arch bridge in Czechoslovakia; D. T. WRIGHT on Highway Bridges in Canada and M. NOVAK on foundations for vibrating machinery — in the "Publications".

As so many subjects have been discussed under Theme VI no general conclusions are possible. It can, however, be said that composite action construction, both of steel beams with concrete and of prestressed concrete beams with concrete has made considerable progress in recent years and that reasonably satisfactory methods of design, supported by many static and fatigue tests, have been developed in several countries, although, as yet, there is no finality or uniformity in the recommended procedures.