The collapse strength of tubular steel scaffold assemblies

E. LIGHTFOOT & G. OLIVETO

Mr B. G. R. Holloway, F

Scaffolds for building work with opportunity to tie back to the building itself are mainly for access by the work force, and are often called on to carry relatively light loads from building materials.

72. In an investigation with which I was concerned for temporary bridge supports some years ago, it was concluded that the foundation is of first importance and should be designed to ensure that tilting and settlement are kept to acceptable limits. Also loading tests on the actual ground should be made to determine safe pressures and for assessing the possibility of settlement.

73. In a paper on the Clifton Bridge, Nottingham, Finch and Goldstein²¹ said, 'The staging for the end spans was of normal steel scaffold tubes, the maximum design load per tube being 3 tons. . . . Since the end span was supported in an unstressed condition for a considerable time, special care was taken to minimize any settlement of supports. No offset joints in the vertical supports were permitted. Pressure/settlement tests were carried out to ensure adequate support. Construction of the end spans was commenced at the piers thereby permitting slight general settlement before casting the closing section. The calculated permanent load deflexions of the end span were so small as to obviate any camber in the staging.'

74. The loading on the scaffold should be accurately estimated and should include the effects of such winds as may be expected at the site during the use of the scaffold.

75. The design should be considered on a basis similar to that adopted for normal steel frameworks, particularly in respect of the effect of eccentricity of connections and the provisions made for reducing the effective length of long columns.

76. The factor of safety should take into account the effects of uncertainties in distribution of the load on the scaffold due to flexibility of the top grillage system and the possibility of foundation settlements, and deflexion of the supported structure.

77. The possibility of exceptional loads due to manipulating the bridge section under, for example, traversing them sideways, and the effect of impact when lowering must also be taken into account.

78. The Author's reference to the computer program which allows for instability effects, coupler flexibility and offset members no doubt could be programmed to take these effects into consideration.

79. It is most important that fully detailed drawings should be made of bridge scaffolding, indicating all the members required including bracing. Particulars of connection must be clearly defined with regard to the evidence of undue eccentricity. The detailed arrangements of the grillage at the top of the scaffold must also be correctly

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detailed. It is also important that scaffolding is inspected to ensure its proper construction.

80. Bridge scaffolds for heavy loadings must be completely braced.

81. The question of effective lengths for local buckling is most important. The centres of intersection are considered to be too short in view of the eccentricity of connections, but an estimate of twice the centres of intersections would be over-conservative on account of the effect of the connections. An effective length of 1.5 times the centres of intersection would therefore appear to be adequate.

82. This compares with the Authors' figure of 1.2 times the lift height for scaffolding not completely triangulated.

83. Taking these facts into account it would appear that the failure of tubular temporary bridge support structures is much more likely to be due to elastic instability than plastic failure.

84. A number of these points are covered in reference 17.

Dr Lightfoot and Dr Oliveto

In Germany new specifications to ensure safety against foundation settlements in falsework are under consideration. The measures described by Finch and Goldstein²¹ for the construction of the end spans of the Clifton Bridge at Nottingham effectively avoided such difficulties there, but some of the failures in more recent years in Germany have been ascribed, in part at least, to unexpected settlements. The difficulties of analysing and designing falsework systems to allow for possible random settlements are formidable, yet the Germans seem to believe that such contingencies may yet need to be allowed for by calculation and certificated checks.

86. Windage can be easily included in design calculations provided relevant drag coefficients are known. Some full-scale research into this problem has recently been instigated by the Building Research Establishment.

87. The flexibility of top grillages, particularly in re-distributing loads into falsework standards as failure approaches with increased loading, can be included in the computer programs already developed. However, the cost is prohibitive for design at present, so simple generalizations would need to be deduced from a series of representative problems.

88. Most scaffolding firms produce comprehensive detailed drawings for falsework with all the bracing members indicated. However, the jointing of timber beams in the formwork is usually left to the carpenters. It might well be found desirable in future to pre-determine the locations of such joints, or to make some regulations about their distribution.

89. When considering effective lengths it is necessary to take account of the bracing arrangements. Access towers are often under-braced; in such cases failures under factored loading occur largely by elastic instability, with a multiplying factor greater than unity to be applied to the vertical lift height. In bridge support systems the bracing is usually sufficient to prevent any appreciable sway displacements developing at collapse under factored loading. Such fully-braced structures collapse by elasto-plasticity; they are 'imperfection-sensitive'. However, the effective lengths to be used will be less than those occurring with under-bracing.

90. The possibility of estimating effective lengths in under-braced and fully-braced skeletal space structures by practicable design office methods is under consideration at the moment, the object being to avoid large computer calculations but to improve on the existing effective length estimation methods. Mr Holloway's suggestion of a factor of 1.5 against local buckling would, we think, be well on the safe side for most scaffold assemblies.

Reference

21. FINCH R. M. and GOLDSTEIN A. Clifton Bridge, Nottingham: design and construction. *Proc. Instn Civ. Engrs*, 1959, 12, Mar., 340.