

No. NHV-11 (6)/73

Dated the 19th November, 1974

To

The Chief Engineers of all the State PWDs and Union Territories

Sub : Ensuring safety of bridge structures-Guidelines for Engineers

Consequent upon the failure of a major Highway Bridge due to yielding of one of its foundations, the Government of India appointed a Technical Committee of Experts to suggest ways and means of avoiding similar failures in future in addition to investigating the causes of the damage. Flowing from the recommendations of this Committee some guidelines are given in the subsequent paragraphs for engineers engaged in the planning design and execution of bridge projects.

2.1. Need for proper advance sub-surface investigations

2.1.1. Before proceeding with the project preparation sub-surface explorations are very important and should always be insisted upon so that a clear appreciation is available of the types of strata to be met with at different depths. Both visual examination and scientific and expert identification of these strata should be carried out for proper classification, properties, bearing capacity and settlement characteristics, so that level of foundations and type of foundations can be decided judiciously. In this connection, it may be advantageous to have recourse to modern methods of foundation investigation, such as refraction geophysical surveys to determine depth of bedrock or resistivity geophysical surveys to distinguish the overall characteristics of over burden when rocky strata is expected in the beds of rivers. The adoption of these methods would lead to a quicker appraisal of overall foundation conditions and also minimise the required drilling effort for sub-surface exploration.

2.1.2. Any phenomenon of unusual nature, such as, the occurrence of artesian conditions during boring and presence of sulphates, pockets of cavities, altered rock zones, and the like, must be identified and investigated thoroughly.

2.1.3. The safety of a bridge structure, finally constructed, depends to a very large extent, upon the accuracy of these sub strata investigations and, therefore, it should be ensured that the investigations are exhaustive and complete in all respects and are carried out with great care and accuracy.

2.2. Coordination with Geologists

2.2.1. Misjudgement in the identification of the strata on which well foundations are to be rested may lead to failure of a bridge. While it is not uncommon to come across sub-surface stratification wherein comparatively harder variety of strata overlie pocket/pockets of weak strata, there may also be cases where the same type of strata at different depths and locations may be in different stages of disintegration. While several State Public Works Departments, Central executive agencies and the Ministry of Shipping and Transport (Roads Wing) have, amongst their engineering cadre, engineers who have acquired expertise in soil mechanics, it is felt that adequate emphasis is not being laid on the knowledge of geology, particularly rock mechanics. It is essential that expert opinion with regard to the suitability of the rock strata available for foundations is obtained by associating a qualified geologist with the work of subsurface explorations, especially in the case of major bridges with foundations on rock.

2.3. Need for frequent site inspections by officers responsible for according approval

2.3.1. According of approval to the suitability of foundation strata and design of all important components of bridges should be on the basis of actual site inspection by the officers responsible for according approval.

2.3.2. It is also necessary to ensure that the assumptions made in the design regarding levels, safe bearing capacity and nature of foundation strata and the like are actually realised at site. Changes, if any, in the hydraulic, strata conditions and other soil characteristics from those assumed in the design should be kept in view and reviewed prior to and during execution, as may be required. For this purpose the design engineers should be in constant association with the works by frequent site inspections.

2.3.3. Identification of exact foundation strata

To avoid future complications in respect of bridges founded on rock, wherever the locations of the piers and abutments materially differ from the contemplated initial locations where borings were originally done, it is imperative to take new borings at the final locations of the piers and abutments in advance of the commencement of the work and decide about the required depth of foundations and the strata on which the foundations will rest and review the design.

2.4. Construction techniques

In case of bridge foundations on rock, even-seating of well foundation is essential. Further, it would be desirable to take the well cutting edge into rock, where necessary by adopting pneumatic sinking, if required, the depth being dependent in each case on the type, nature and quality of the rocky strata met with.

2.5. Need for proper 'after construction inspections and maintenance'

2.5.1. Some states in the country have laid down procedures for regular inspection of bridge works for the purpose of their proper maintenance. However, in several states no regular practice is in vogue for detailed periodic inspection of bridge structures.

2.5.2. Proper and timely inspection of all components of bridges including the foundations and the training works etc. is absolutely essential and should be strictly enforced. Such a system is in vogue in the Railways. To achieve this objective, it is suggested that the following procedure may be considered for adoption by all State Public Works Departments/executive agencies.

- (i) Complete up-to-date records relating to the bridge structure, viz., the design data, detailed drawing completion drawings, the construction history and field observations after completion of structure shall be available with the officer-in-charge of its maintenance.
- (ii) Apart from the normal inspection by junior departmental officers, inspection of the major bridges, shall be carried out by an officer, not below the rank of an Executive Engineer. Such an inspection would also be necessary for medium and minor bridges where defects have been noticed and/or serious problems are apprehended.
- (iii) There shall be at least two inspections every year one prior to and the other following the monsoon season. In case of problematic bridges more frequent inspections may be called for.
- (iv) The inspection should cover all facets of the bridge structure including examination of the conditions of foundations where possible, scour around foundations, conditions of the sub-structure, articulations, bearings, superstructure, deck slab, wearing course, wheel guards and guard rails, all members of steel and timber trusses, stringers and floor beams, painting of superstructure where applicable, strings and wire ropes, spurs and bunds, other protective works and approaches.
- (v) Special care shall be taken to check up the relevant levels of the structure to ensure that the bridge is on grade as per original design and construction and there has not been any undue settlement of foundation. The time gap between successive observations of this nature could be increased, if there are no problems noticed.
- (vi) Where changes in the river course or large scale scouring are manifested, the bed contours may be plotted by taking soundings to study the effect of any change in the bed configuration.
- (vii) A check list should be formulated to facilitate these inspections so that none of the required items needing examinations is lost sight of.
- (viii) Further it is equally important to take timely steps to implement thoroughly the suggestions and recommendations based on these inspections well in time.